THE MOTOR ELECTRICAL MANUAL

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THE MOTOR ELECTRICAL MANUAL

A practical and fully illustrated handbook and guide for all motorists, describing in simple language the principles, construction and working of the electrical appliances used on cars. How to keep ignition, lighting, starting and auxiliary devices in working order. Glossary of electrical terms. Units, tables, etc.

SEVENTH EDITION

Published by

TEMPLE PRESS LIMITED,
5-17, Rosebery Avenue, London, E.C.1.

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5/2/36. Printed in Great Britain.

629.2
1.103

PREFACE

THE demand for the completely re-written sixth edition of this manual has been such that this, the seventh edition, goes to press with but few amendments.

There is no doubt that the least understood feature of the modern car is the electrical equipment, and, whilst certain classes of electrical repair work may need the attention of a specialist, an understanding of the principles underlying the functioning of the electrical accessories will enable amateurs, in many cases, to undertake their own maintenance work.

This manual does not pretend to give information of an advanced nature; its purpose is to treat as non-technically as possible with the upkeep of batteries, ignition systems, dynamos, and so on. No attempt has been made to deal with repairs or adjustments obviously beyond the skill of an amateur mechanic. It is better to advise that such work be entrusted to an electrical service station.

DEPARTMENT OF AERONAUTICAL ENGINEERING
INDIAN INSTITUTE OF SCIENCE.

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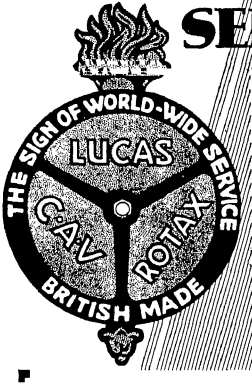

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LIGHTING · STARTING
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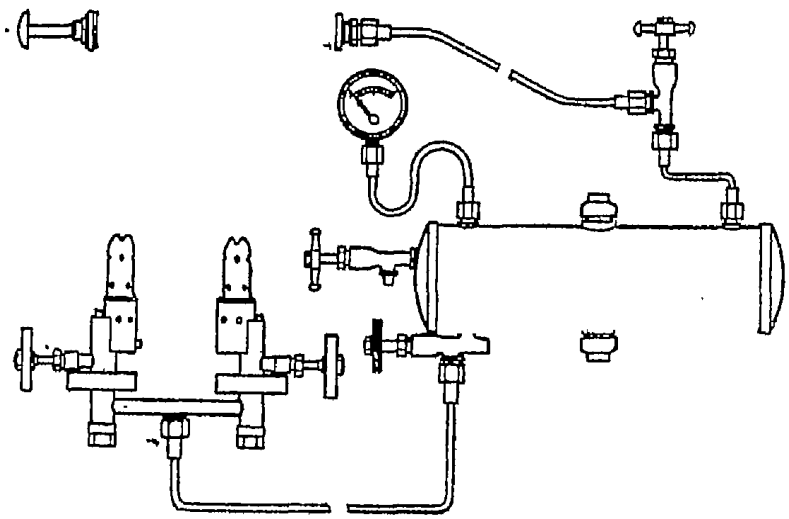
CHAPTER I.

Introductory.

THE use of electricity in connection with the running of a car is becoming more and more extensive. In the very early days it was used only for ignition, in which function it proved more convenient—but not always more reliable—than the hot-tube system which it replaced.



The burner arrangement of a two-cylinder tube ignition system. The blowlamps heated platinum tubes screwed into the cylinders.

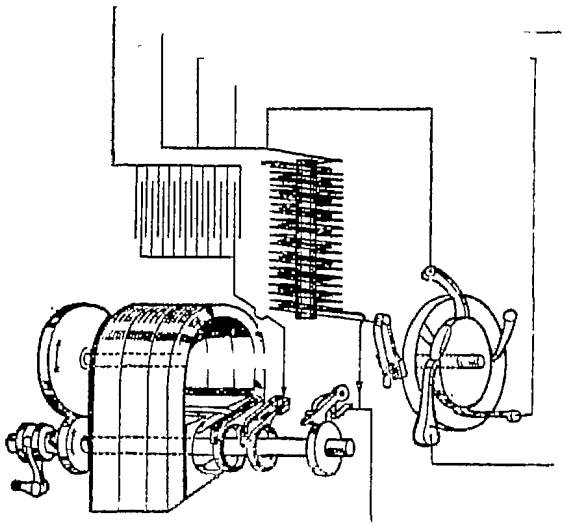
As experience in manufacture was gained, so reliability increased, but the batteries remained somewhat messy devices and were apt to become discharged unexpectedly. Thus they had to be taken to a charging station, as car dynamos had not been introduced.

This drawback operated greatly in favour of the magneto, which, clumsy as it was at the time, would produce sparks without the aid of externally applied current.

There were two types of magneto in use in the early days: the high tension, similar to that of the present time, and the low tension, which worked in conjunction with a tappet-operated make-and-break within each cylinder.

Discarded Ignition Systems.

This type did not remain in use very long as, in spite of its producing large and very hot sparks—actually, they were more in the nature of flaming arcs—the make-



An Eisemann high-tension magneto of the past. It consisted of an alternator delivering current to a coil. A half-time shaft drove the wipe-contact distributor.

and-break system proved very troublesome, and precise timing was difficult to maintain.

The drawbacks were partly overcome by the introduction of a magnetically operated make-and-break, but this, in turn, was discarded, and low-tension ignition no longer finds a place on cars. It is still used, however, on some types of large gas engine.

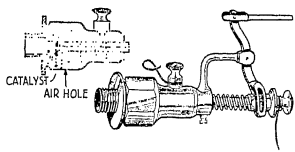
Careful attention to design and manufacture soon resulted in the high-tension magneto becoming a very efficient instrument, so that motorists had no more use for coil ignition.

In a catalytic ignition system of the early days a spiral of osmium wire was made incandescent by battery current. The spiral was fitted in the end of a movable sleeve carried in a body screwed into the cylinder head. Soon after starting the battery could be switched off, as the heat in the cylinder would keep the spiral glowing.

Variations in timing were effected by moving the spiral in the sleeve, closer to or farther from the mixture, whilst the engine was stopped by pulling the sleeve right back, thus exposing an air hole by which the spiral was cooled. This scheme did not prove very successful.

Acetylene and oil lighting with its attendant innumerable drawbacks was accepted as a necessary evil, simply because there was nothing better. It was realized, of course, that electric lighting would be ideal, and it was not long before this system began to be applied.

At first it was usually an "extra," costing anything up to £50 if a dynamo formed part of the equipment.



An early compression-ignition scheme. After initial heating by a battery the catalyst remained incandescent owing to the cylinder heat.

Progress in design and manufacture rapidly brought down the price, and eventually the system was standardized on the more expensive cars. To-day even the lowest-priced vehicles are fully equipped.

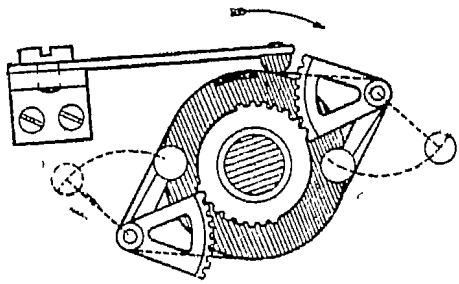
Controlling Dynamo Output.

One of the early troubles with dynamos was to control the output. Schemes which incorporated slipping clutches, centrifugal governors operating variable resist-

ances and so on were adopted, only to be afterwards discarded. Eventually the third-brush system was introduced and has remained in regular use ever since.

This system is not ideal, however, as, although the maximum output of the dynamo is effectively controlled, the battery does not necessarily receive the nicely balanced current that it requires. The charging rate may be too high or too low, according to circumstances.

For this reason dynamos with compensated voltage control are now being used. They ensure that the bat-



Automatic advance and retard for coil ignition was used many years ago. This sketch shows it applied to a wipe-contact breaker.

tery shall be maintained in a correctly charged condition irrespective of the calls made upon it by the starter, lamps and so on.

Other fairly recent improvements in the electrical equipment of cars include automatic switches for cutting in the starter whenever the engine stalls, a starter switch combined with the accelerator pedal, means for automatically controlling the ignition timing in accordance with engine speed or load or both, and concealed-motor dual screen wipers.

Automatic timing control is not, by the way, a new idea. Very many years ago it was applied to coil ignition. A toothed sleeve on the contact-breaker plate had meshing with it two toothed sectors carrying bob-weights. As the engine speed increased the weights were thrown outwards, thus rotating the contact-breaker

plate about the driving spindle and advancing the ignition.

The reliability of the modern electrical generating and storage system—the dynamo and the battery—is now so far beyond question that more and more use is being made of it.

In addition to ignition, lighting and starting, current is required for screen wipers, traffic signals, petrol gauges, cigarette lighters and other purposes. Thus, in comparatively few years, electricity has become an integral and most essential part of every car.

Understanding Electrical Systems.

Because of this owners who take an interest in their vehicles will find it necessary to understand the electrical system. Many, however, seem to regard it as something entirely beyond them, and are, indeed, almost afraid to touch any part of the equipment.

It should be realized, however, that mere maintenance routine and, in some cases, even repair does not involve interference with the windings of coils or armatures; in fact, as a perusal of this handbook will clearly show, the work is largely of a mechanical nature, and no very close acquaintance with electrical theory and practice is needed.

We are concerned here, primarily, in describing how the various pieces of apparatus function, in what manner they can give trouble and how they may be put right. The small amount of electrical theory necessary for a proper understanding of the principles involved is dealt with in easily understood terms. An introduction to these is given in the next chapter.

CHAPTER II.

Theory and Principles.

ELECTRICITY can exist in innumerable forms; in fact, the trend of modern scientific thought is that everything is, as it were, made of electricity. Interesting and, indeed, important as this theory may be, it does not concern us at the moment; we shall confine ourselves to considering that form of electricity which is generated by a dynamo, stored in a battery and used by other devices. Although they will, of course, be treated separately, magnetos are closely related to dynamos, because both are self-contained producers of electric current.

The action of the machines is based upon the fact that if a closed loop of wire be rotated between the poles of a U-shaped permanent magnet two surges of electric current per revolution will be induced in the wire. The surges or waves will flow in opposite directions and will rise and fall in value, or intensity, from a minimum to a maximum.

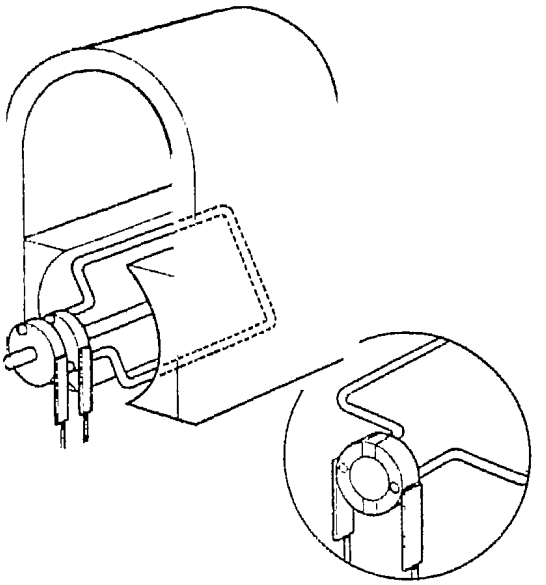
Naturally, the current so produced is extremely small, but by arranging a large number of turns or loops of wire, wound on a soft-iron former, powerful currents may be generated. The assembly of wires and former is known as an armature.

If the ends of the wires be connected to two metal rings insulated from each other and arranged to rotate with the armature, the current can be collected by means of two brushes. These may be of metal or carbon; they are insulated from the body of the machine and bear lightly upon the two rings—one on each.

The current generated by these means is of the same nature as that in the simple loop and is known as alter-

nating, because it changes direction, that is, polarity, twice per revolution. Each brush is, therefore, positive and negative alternately, also the current strength varies, as already explained.

This principle, very greatly elaborated, of course, is the one upon which the giant turbo-alternators in



This very simple dynamo with slip rings and brushes would produce alternating current. By using a commutator (inset) the current becomes uni-directional.

modern power stations work. Because of the variations in polarity, however, alternating current cannot be used for battery charging.

Direct-current Dynamos.

For this purpose a constant-direction current is needed, and it can be obtained either by rectifying alternating current by means of a separate apparatus or in the dynamo itself. The last-named course is adopted on cars because it is more convenient. It entails modifying the armature and providing a commutator, instead of a pair of slip rings, for current collection by the brushes. The purpose of the commutator is to convert the alternating current into one having a uni-directional

flow. Thus one brush is always positive and the other negative.

It must be made clear that in the normal type of dynamo the permanent magnet of our elementary machine is not used. Instead, there are wire-wound electro-magnets provided with pole pieces shaped to embrace the armature. The magnets are arranged within a metallic casing, the end covers of which carry the armature bearings. The brushes are mounted in a holder secured to one of the covers.

Electrical Measurements.

The amount of current that a dynamo will generate depends upon several factors which need not be considered here; but there are two terms in connection with the output which must be explained. These are volts and amperes.

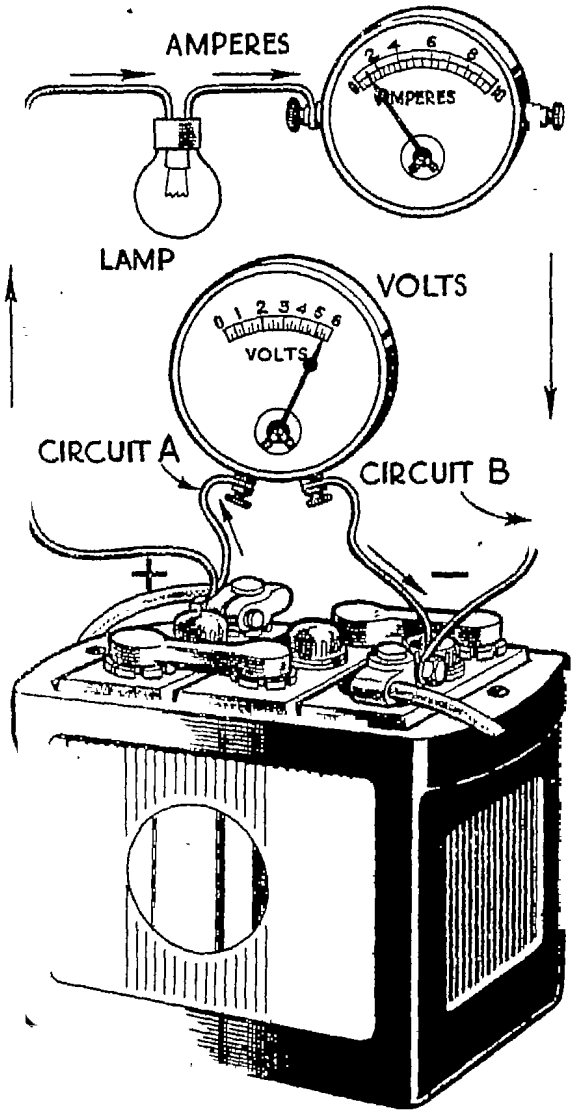
The volt is the unit of electrical pressure, just as pounds per square inch indicate steam pressure. The ampere—or amp. as it is usually called—is not quite so easy to explain however. Very roughly, it is the unit of quantity, but not, as it were, of static quantity, such as a gallon of petrol in a tank. It is, rather, a measure of the rate of flow of the current in a circuit.

Another electrical measure which may well be dealt with now is the watt. This is the unit of energy consumption and is the product of volts multiplied by amps. Thus, a headlamp bulb taking a current of 3 amps. at a pressure of 12 volts is rated at 36 watts. One electrical horse-power is equivalent to 746 watts.

For costing purposes, electricity supply companies reckon current used in terms of units; that is, the charge made is at so much per unit. One unit is equal to 1,000 watts for one hour. Thus, an appliance rated at 100 watts would consume one unit in 10 hours.

A knowledge of watt and unit calculation is useful when estimating the cost of running an electric radiator warmer, battery charger, small motor for workshop use, and so on.

Although, perhaps, of less importance to motorists than to apparatus designers, electrical resistance must be understood. The unit of resistance is the ohm, and a circuit is said to have a resistance of 1 ohm when a current of 1 ampere can be passed through it at a pressure of 1 volt.



The voltage of a battery is checked by connecting a voltmeter (circuit A) across the terminals whilst the current taken by a lamp is measured by connecting it in series with an ammeter (circuit B). An ordinary ammeter should never be connected directly across the battery terminals.

A knowledge of Ohm's law can be very useful in tracing electrical troubles. The law states that "the strength of a current varies directly as the voltage and inversely as the resistance of the circuit."

$$\text{Therefore } I=\frac{E}{R},\ R=\frac{E}{I} \text{ and } E=IR$$

where I = current in amps.
E = electromotive force (E.M.F.) in volts.
R = resistance in ohms.

This makes it clear that the greater the resistance the less the current flow, from which it follows that the wire, or other conducting path, should be of ample size for the load.

Current Conductors.

Here we arrive at the question of conductors. Nearly all metals are conductors, some being vastly better than others. Certain non-metallic substances also permit the flow of electricity; carbon, for instance, and water, especially when it is mixed with a little salt or acid.

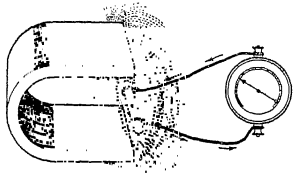
Amongst metals, silver has the highest conductivity, but for various reasons—cost, mainly—it is not used in the form of wire in motorcar electrical apparatus. With very few exceptions, the current-carrying wires on a car are made of copper, which is the standard "best" conductor.

At the other end of the scale we find metals which offer a very high resistance to current flow. These are of value, however, when drawn into wires, in providing special forms of circuit where it is desired to restrict the amount of current which passes. Certain nickel alloys are chiefly used for making resistance wires.

The joints of a conductor must be carefully made as oxides and dirt set up a resistance to the current. That is why on single-pole earth-return wiring systems a lighting fault can sometimes be traced to a rusty lamp mounting.

Another important point in connection with conductors is that they must be of a size sufficient to carry

the required current. A thin wire, if called upon to transmit a heavy current, will overheat and, in extreme cases, melt. This, of course, is how fuses work. Clear examples of conductor size for a given job can be seen on a car where the leads to, say, the side lamps are comparatively thin, as they have to carry only one or two amps. On the other hand, very heavy cables connect the battery to the starter motor because, at times, there may be a current flow of 200 amps. or more.



If a conductor be moved in a magnetic field a flow of current is produced in the circuit. This is the working basis of a dynamo or a magneto.

If thin wires were used for the starter there would not only be a considerable risk of overheating, but, in addition, the voltage drop caused by the resistance of the wire would bring about an appreciable reduction in the power of the motor, according to the rule: amps. × volts = watts, and 746 watts = 1 electrical horse-power.

All current-carrying wires on a car must, of course, be insulated; that is, they must be protected by some material which is a non-conductor of electricity. One of the most convenient and efficient non-conductors is rubber. Others in regular use are cotton, oiled silk and enamel. These, being flexible, can be applied to wires.

Rigid insulating materials are also needed in the construction of electrical components, and some must possess a fair amount of mechanical strength. Some,

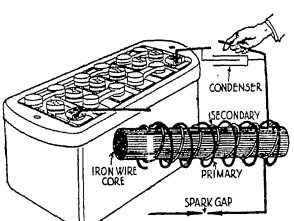
also, must withstand considerable heat, as, for instance, the insulators of sparking plugs.

High-tension currents have a considerable tendency towards leakage, hence the thick coating of rubber which surrounds the sparking plug leads. For low-voltage work there is less need for heavy insulation, even when the wires are carrying a considerable current.

Here, again, a comparison may be found between the starter cables and the plug leads. The first-named may carry anything up to 200 amps. at 12 volts, whilst the plug leads deal with, possibly, 10,000 volts, but only a minute fraction of 1 amp.

Principles of Induction.

Before closing this chapter it is necessary to deal with the phenomenon of induction, because on this is based the working of coils and magnetos.



The elements of a spark coil. A discharge occurs each time the primary circuit is broken.

We have already seen how a current may be generated in a wire which is moved rapidly near the poles of a magnet, and how an alternator or a dynamo is an elaboration of the principle. The current is, however, of the low-tension order and unsuited for ignition purposes, for which very high voltages are needed.

A current passing through a coil of thick insulated wire wound on a bar of soft iron will cause the iron core to become magnetic, as in the case of electro-magnets in a dynamo, and if the circuit be suddenly broken there will be a bright flash at the break due to the influence of the turns of wire and the magnetism in the soft-iron core. This is the phenomenon of self-induction.

In coils and magnetos we go a step farther by providing an additional coil of wire wound over the first, but insulated from it. The coils are known as the primary and the secondary. With this arrangement, sudden rupture of the primary circuit induces a very high voltage in the secondary, and if this be arranged so that the two ends are not quite touching, a spark will jump the gap.

The necessary magnetism can be obtained either by a battery, as in coil ignition, or by permanent magnets, in the case of a magneto. Naturally, the principle must be elaborated considerably for practical use. One important point is that some form of buffer or reservoir must be provided to deal with the self-induced electricity in the primary circuit.

The Action of a Condenser.

A device known as a condenser is used for this purpose; it may consist of a large number of alternate layers of tinfoil and mica, or waxed paper. The foils are arranged so that, for example, the even numbers are connected to one terminal and the odd numbers to the other.

The unit of electrical capacity, by which condensers are measured, is the farad, but as this is much too large for practical purposes, another unit, the micro-farad—one millionth of a farad—has been adopted. The average capacity of a magneto condenser is .01 mfd., whilst .2 mfd. is usual in a coil.

In either case the condenser is connected across the break in the primary coil, with the result that the self-

induction impulse, instead of causing a flash at the break, is shunted into the condenser. This, however, at once shunts it out again, and the effect of the rebound, as it were, is to induce a much higher pressure in the secondary windings. Thus the weakly spark of our elementary induction coil becomes a powerful discharge capable of jumping a gap of $\frac{1}{4}$ in. or more.

The transformation of the current by a coil is interesting. A pressure of 6 volts or 12 volts at about 2 amps. in the primary becomes converted to about 10,000 volts, and only a very small fraction of an ampere in the secondary. In the next chapter the actual construction and working of coil ignition systems is fully explained.

CHAPTER III.

Coil Ignition.

A COMMENDABLE feature of coil ignition is its general simplicity. The normal electrical system of a car provides for the generation of current by means of a dynamo, therefore if the current can be made to operate the ignition system the need for generating a further suppy with a magneto is avoided.

The principle by which low-tension electricity may be transformed into high-tension has already been explained. We are therefore in a position to consider the construction of a normal type of ignition coil.

The iron core, instead of being solid, consists of a bundle of soft iron wires, as this arrangement prevents the formation of eddy currents in the core itself by induction. A solid core also tends to overheat.

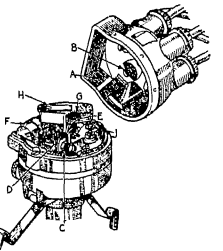
Only a few hundred turns of copper wire are used for the primary winding, the resistance of which usually is not more than one ohm. The secondary winding, however, consists of at least 16,000 turns of very fine copper wire, generally enamel insulated, and has a resistance of up to 4,000 ohms.

The bare wire has a diameter of about .004 in.—a little thicker than a human hair—and the enamel covering is not more than two ten-thousandths of an inch thick. In addition to the insulation provided by the enamel, layers of varnished silk separate the layers of wire, and the whole assembly may be impregnated with paraffin wax. Some makes of coil have the primary wound outside the secondary, an arrangement which possesses certain advantages, such as greater mechanical strength and improved heat dissipation.

Coil-winding Connections.

In either case the internal connections are similar. One end of the secondary is led out to the high-tension terminal on the coil cover, the other end is connected internally to one end of the primary, to which also a wire is attached leading to one of the low-tension terminals on the cover. This terminal is usually marked SW—denoting switch.

The remaining end of the primary connects with the second cover terminal, marked CB—contact breaker.



The main parts of a Lucas distributor: (A) Distributor cover, (B) H.T. electrodes, (C) contact breaker adjusting nut, (D) locknut, (E) cam, (F) condenser, (G) rotor, (H) rotor electrode.

There are no moving parts in a coil and, of course, no attempt should ever be made by an amateur to remove the windings from the case.

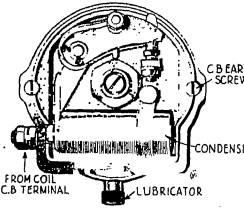
It should be mentioned here that the type of coil with which we are dealing is known as a non-trembler. This is to distinguish it from another type, now hardly ever used, in which a trembler, or vibrating contact breaker, is incorporated. The general construction is similar to that of a non-trembler coil, but one end of the laminated core is exposed and the magnetism in this operates a spring-mounted armature exactly on the principle of a domestic electric bell.

When current is applied the armature vibrates at immensely high speed and a constant stream of sparks can be drawn from the H.T. terminal. This sounds attractive from an ignition efficiency standpoint, when compared with the single spark per "break" of the non-trembler coil.

In practice, however, there are many drawbacks, especially where multi-cylinder high-speed engines are concerned, and, apart from functional difficulties, the "stream of sparks" may be no more effective than a single discharge in the very minute fraction of a second during which ignition occurs.

Construction of a Distributor.

The distributor head of the standard non-trembler coil system consists of three main components: the contact breaker, the condenser and the H.T. distributor



A standard Lucas distributor head with various parts named. The C.B. earth screw also serves to hold the breaker plate to the distributor body.

itself. A spindle, driven by the engine at camshaft speed (i.e., half crankshaft speed), carries at its upper end a cam having as many lobes as there are cylinders.

Bearing on the cam is a heel piece secured to a rocker arm, which, in turn, is carried on a pivot pin. A contact, usually of tungsten, which is a hard, non-tarnishing metal, is riveted in the opposite end of the rocker arm,

whilst a spring acting on the arm causes the contact to bear against another fixed to, but insulated from, the distributor casing. This contact has a screwed stem, so that it may be adjusted to the correct gap, which, in the case of a coil contact breaker, is about .015 in., although in some cases .02 in. is recommended. The condenser, usually of cylindrical form, is mounted in the distributor head and may be provided with lugs for connecting across the contact-breaker points.

Why Tungsten is Used.

Reverting, for a moment, to the contacts, it may be pointed out that, contrary to a fairly general idea, tungsten is not used on account of its cheapness, as compared with platinum. With coil ignition tungsten is superior to platino-iridium alloys, as it resists erosion and the tendency for the metal of one contact to be transferred to the other.

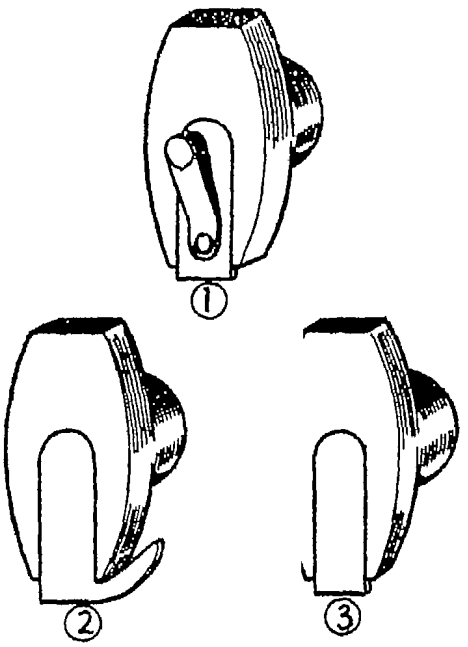
Platinum-alloy contacts are, however, desirable in magnetos where the circuit conditions are different from those obtaining in coil systems; but there is a difficulty with the "precious-metal" alloy contacts in that if oil or petrol vapour be present they are apt to burn away very rapidly. Tungsten, on the other hand, is practically unaffected by these vapours.

For the foregoing reasons it will be clear that to substitute platinum contacts for tungsten in a coil contact breaker, in the belief that a superior performance will be obtained, is quite wrong.

We can now return to our description of a distributor.

An extension of the main driving spindle above the cam carries a rotor, usually moulded from Bakelite or some similar insulating material. A metal electrode is fitted on the top of the rotor, which is roughly T-shaped, the extension on the side opposite the electrode being provided for balance. The rotor is readily detachable, and to ensure its correct replacement for timing purposes it is slotted to engage with a projection on the spindle.

The distributor cover, moulded from Bakelite, carries as many terminals as there are cylinders and, in addition, a centre terminal which accommodates the main high-tension lead from the coil. Within the casing the plug lead terminals are provided with metal electrodes, arranged in a circle and machined so that when the cover is in place the rotor clears them by about .01 in.,



Distributor rotors. The spring-contact type (1) is giving place to the plain type (3), whilst (2) is designed to prevent backfiring on four-cylinder engines when starting.

but it is not important for this dimension to be closely accurate.

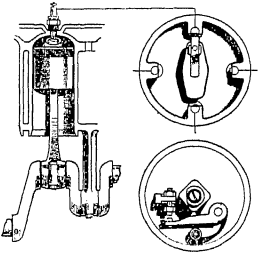
The centre electrode is usually made of carbon and spring-loaded, so that it presses lightly on the metal electrode of the rotor, thus allowing the current from the coil to pass along to the electrode tip, whence it jumps the gap to the cylinder electrodes.

Sometimes, instead of a carbon brush the cover moulding carries a metal stud, against which presses a bronze button on the end of a springy arm riveted to the rotor electrode.

The Cycle of Operations.

It has already been mentioned that one of the low-tension wires on the coil—the one leading from the terminal "C.B."—goes to the contact breaker; in practice it is connected to a terminal on the distributor casing and is wired internally to the rocker arm, the other contact point being earthed. The circuit being thus completed, the cycle of events in the operation of the ignition system is as follows:—

The rotating cam on the distributor shaft causes the contact-breaker points to make and break alternately. Each time a "break" occurs, as we have already seen, a high secondary voltage is induced in the coil and current passes along the H.T. lead to the electrode of



Ignition timing. With the piston at T.D.C. the cam has opened the contacts and the rotor tip is in line with the electrode.

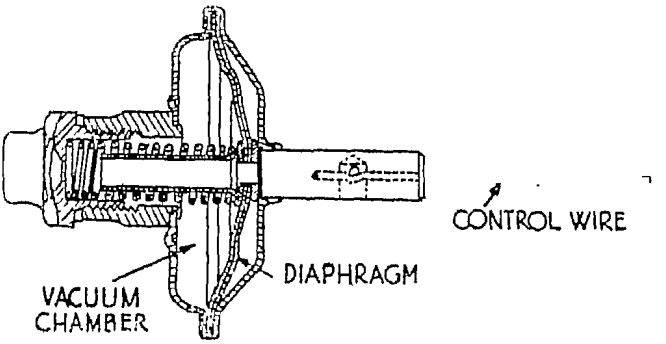
the rotor, which at that instant will be opposite one of the terminal electrodes, from which a wire leads to a sparking plug. The current jumps the gap between the rotating and fixed electrodes, and then passes across the sparking plug gap to earth. The provision of the gap in the distributor has the effect of intensifying the discharge at the plug gap.

Immediately after a spark occurs the rotating cam allows the contact-breaker points to be closed by the

spring on the rocker arm, after which the cycle of operations is repeated for the spark next to occur, in firing order.

Automatic Timing Control.

The majority of modern distributors are provided with automatic timing control. This is contained in the base of the distributor head and consists of bob weights, which move under the action of centrifugal force and cause the cam to rotate slightly relative to the shaft



Ignition timing control by engine suction is possible by means of this vacuum unit. It is used in conjunction with centrifugal control.

which is driving it; thus, as the engine speed rises, the cam advances, so causing the spark to occur earlier. With falling speed the bob weights, as it were, slow down the cam, thus retarding the ignition.

Another method of control consists of using the vacuum in the induction manifold. This scheme, when employed in conjunction with centrifugal control, gives a very accurate timing as the correct ignition point is governed by load as much as by speed. The vacuum control consists of a diaphragm in a metal housing. One side of the housing is piped up to the induction manifold, so that the varying suction causes the diaphragm to flex. By means of suitable linkage, therefore, the flexing movement can be made to rotate the distributor head through a small angle, thus altering the timing.

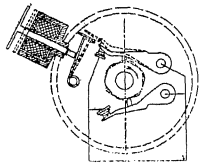
There are certain modifications of the standard type of distributor which must be explained. On very

high-speed engines, especially those having six or eight cylinders, it has been found that one contact breaker does not allow a sufficient time interval for the current in the coil is build up during the "make" period. For this reason distributors having double contact breakers are sometimes used, the arrangement being such that on a six-cylinder engine a three-lobe cam is used, whilst one having four lobes is fitted on an eight-cylinder engine.

The Time-constant.

An idea of the very rapid manner in which a coil has to work can be gained from the following figures. Assuming a 12-volt coil in which the primary current is limited to 3 amps., it can be shown, by a calculation which need not be made here, that the time-constant in the primary circuit will be 1-400th of a second.

The contact period, that is, the period of "make" at the contact-breaker points, is $\frac{1}{8}$th of an engine revolu-



The Delco-Remy electro-magnetic advance and retard control system. A solenoid cuts out the "retard" contact breaker when the engine reaches a certain speed.

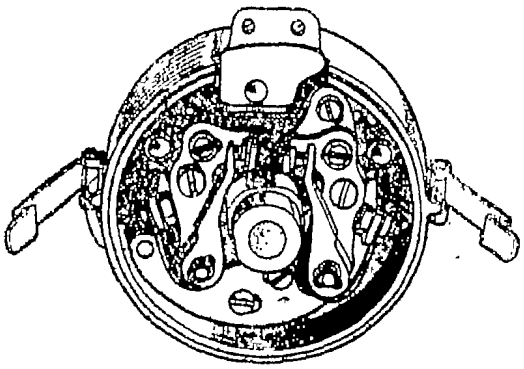
tion, and when the engine is running at 4,000 r.p.m. this period is 1-400th of a second, which, as we have seen, is just the amount that the coil can manage. Any increase in speed will bring about a decrease in sparking intensity, and may even result in definite misfiring.

The foregoing is merely an indication of what can happen in a multi-cylinder high-speed engine. In practice, of course, higher speeds than 4,000 r.p.m. can be

obtained quite satisfactorily with single contact breakers, but where absolute efficiency is important, such as in racing, double contact breakers become necessary. An alternative scheme is to use two separate coils and distributor heads, each serving half the number of cylinders, whilst, of course, one can also adopt the dual ignition system, which employs a coil for starting and slow-speed running and a magneto for high speeds.

Avoiding a Burn-out.

One point in connection with coil ignition must not be overlooked. If the engine be stopped with the ignition switched on and the contact points "making,"



For high-speed ignition. The Delco-Remy double-break distributor unit for an eight-cylinder engine.

there will be a continual flow of current from the battery through the coil, and, in the ordinary way, this may result in the coil heating up sufficiently to burn out or, at least, to melt its insulation. To guard against this happening some coils are provided with a resistance in the primary circuit.

As a rule the resistance consists of a small helice of wire mounted under a protective cover on the coil casing. The wire is of a special nickel alloy, which has the property of increasing its resistance with the rise in temperature; thus, during normal running it remains comparatively cool and does not limit the flow of current to the coil. On continual discharge, however, the resistance heats up, and this has the effect of limiting

considerably the current which can pass. By this means the coil is protected and the battery is prevented from discharging rapidly.

On coils not provided with a resistance it is usual to fit a warning lamp in the instrument panel. This causes a red light to show when the ignition is on and the engine is either stationary or running very slowly. The light cuts out automatically so soon as the dynamo begins to charge, but if the engine be stopped accidentally whilst the ignition is switched on, the red light gives an indication that the battery is being discharged through the windings, and thus reminds the driver to switch off.

Having followed this general description of the construction and working of a coil ignition system, the reader will be in a position to understand something of the actual types used on present-day cars. The Lucas distributor heads are substantially similar to the type just described, and they call for very little maintenance attention.

Distributor Maintenance.

With regard to lubrication, the screw-down greaser on the distributor spindle should be given one turn about every 500 miles; the grease used must be of good quality and have a high melting point. Where an oiler is provided instead of a greaser, one or two drops of thin machine oil every 1,000 miles or so will be all that is required.

The slightest smear of vaseline can be applied to the cam about every 3,000 miles, and care must be taken to see that no large quantity of lubricant is used within the distributor casing, as its presence on the contact-breaker points will give rise to trouble.

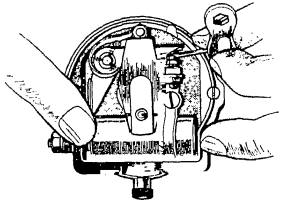
The automatic timing control is lubricated with thin machine oil. One must first pull off the rotor from the top of the cam spindle, and then apply the oil around the edge of the screw which will be seen recessed in the end of the spindle. The screw must not be undone. There is a clearance between it and the spindle for the oil to pass down to the timing control. This attention

should be given about every 3,000 miles. The pivot pin on which the rocker arm of the contact breaker works requires lubricating every 5,000 miles with just a single drop of thin machine oil.

If the distributor is mounted horizontally it will usually be found that the automatic timing mechanism is amply lubricated by oil which finds its way along the spindle from the engine.

In the case of distributors mounted on the dynamo the gear drive should be lubricated with high melting-point grease, but only a very small amount is needed, as any excess may find its way either into the dynamo or into the distributor head, where it will cause trouble.

With regard to cleaning, it is advisable occasionally to remove the distributor cover and to wipe the electrodes with a cloth moistened with petrol, at the same



Setting the contact-breaker gap. The gauge should just slide between the contacts when they are fully separated by the cam.

time taking care to remove any dust which may be present on the under face of the moulding. A certain amount of pitting on the faces of the electrodes is to be expected, but it will do no harm. See that the central carbon brush is clean and moving freely in its holder against the pressure of the light spring, if the distributor be of that type. If it be of the metal-button type, make sure that the contacting faces of the buttons are clean and smooth.

The need for keeping the contact points free from grease or oil has already been mentioned, but if they are burnt or blackened they can be cleaned with a piece of very fine emery cloth and afterwards with a rag moistened with petrol. Excessive pitting or burning of the points is usually an indication that the condenser is broken down, in which case a new one must be fitted.

This can probably be done quite safely by an amateur mechanic if it be of the type held in place by screws. Where any doubt exists, however, regarding ability to do the job, it is always best to take the car to a service station.

When the distributor has been in use for a long time the edge of the rotor electrode will be found to be burnt away somewhat; the effect of this is to increase the gap between it and the electrodes in the distributor cover. A small increase due to burning is of no importance, but when it becomes excessive it is advisable to renew the rotor.

Contact-breaker Gap Setting.

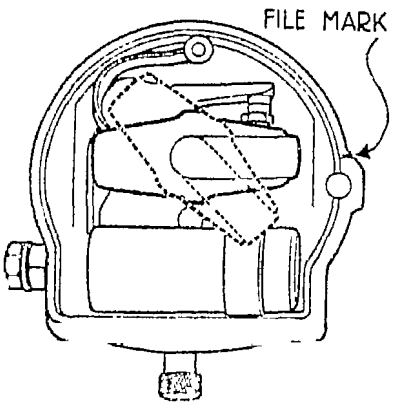
Exact setting of the contact-breaker gap is important, and as a rule a gauge is supplied with the car by which the correct gap may be set. The engine must first be turned by hand until one of the lobes of the cam has separated the points to their maximum extent.

In this position the gauge should just slide comfortably between the points; if there is considerable clearance, however, or, on the other hand, if there is not enough, the adjustment is made by first slacking the lock nut on the adjustable point, and then rotating this by its hexagon head until the gap setting is correct according to the gauge. The lock nut is then tightened.

When the adjustment has been made it may be found that owing to wear or burning the points do not come squarely together. In these circumstances they must be trued by rubbing a thin strip of emery cloth between them or, preferably, by using one of the special carborundum slips which can be bought for the purpose. Having trued the points, a further check with the gauge should be made, because in all probability the gap will

have increased; a further setting, therefore, must be made.

On some types of Lucas distributor and, in fact, on other makes also the contact-breaker adjustment is carried out by moving a plate, on which the points and rocker arm are mounted, relative to the cam. The screws carrying the plate are slackened and the plate moved bodily towards or away from the cam until the gap setting is correct, at which point the screws are



When removing a skew-gear driven distributor head the rotor will turn slightly. A file mark made on the casing can be used as a guide for correct remeshing. The rotor tip should line up with the mark.

again fully tightened. It will be clear, of course, that this adjustment is carried out with the points separated by one of the lobes of the cam, as in the previous case.

Double-break Adjustments.

When dealing with distributors of the double contact-breaker type the two gaps must be maintained exactly to the gauge setting, the correct procedure being as follows: Turn the engine slowly until one pair of contacts has fully opened, then slack the locking screw of the contact-breaker plate and adjust the gap to the gauge in the manner already described. Tighten the locking screw and adjust the other gap in the same way.

It is, of course, necessary with contact breakers of this type that the actual timing of the two breaks shall

be precisely synchronized. Users of Lucas equipment are advised against attempting the synchronization themselves, should any such adjustment ever become necessary, but the work can be carried out quite readily at any of the service stations.

Delco-Remy coils and distributors are substantially similar in design to those of Lucas manufacture. The coils have the primary windings outside the secondary.

Checking Firing Order.

If the plug leads of an engine be detached and "mixed up" it will be necessary to trace the firing order when replacing them. Turn the engine by hand until the piston of No. 1 cylinder is at top dead centre on the firing stroke—as indicated by both valves being fully closed. At that point the rotor in the distributor will be adjacent to one of the cover electrodes. Connect a plug lead from that terminal to No. 1 plug.

Again turn the engine and watch the valve movement. It it be a four-cylinder unit firing 1, 3, 4, 2, the valves of No. 3 cylinder will be the next to reach the "both closed" position. The rotor will have moved round to the next electrode. Connect its terminal with the H.T. lead to No. 3 cylinder. Having found the sequence of two cylinders, it then becomes only a matter of connecting the two remaining leads in the order of distributor rotation. The third electrode must belong to No. 4 cylinder and the fourth to No. 2.

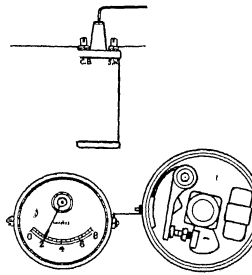
On some four-cylinder engines the firing order is 1, 2, 4, 3, in which case positions 1 and 2 are traced by valve movement and the remaining two follow in sequence. Six-cylinder engines fire 1, 5, 3, 6, 2, 4 or 1, 4, 2, 6, 3, 5; again only two positions need be found for the others to follow according to the direction of rotation of the distributor rotor.

Resetting the Timing.

The actual timing of the ignition with Lucas, Delco-Remy and, in fact, practically all coil distributors is a simple matter. Assuming, for example, that the spark

is to occur at T.D.C. with the control fully retarded, the process consists in turning the engine until the piston in No. 1 cylinder is at the precise top centre on the compression stroke.

The clamping bracket on the distributor body is then slacked; this allows the head to be rotated by hand.



An ammeter, or a lamp bulb, wired in the circuit as shown, will aid accurate timing. The instant that the contacts separate the needle will drop to zero or the lamp will go out.

If the timing is merely being checked or slightly adjusted, it will be found upon removing the distributor cover that the rotor electrode is in a position adjacent to the terminal electrode of No. 1 cylinder plug. A lobe on the cam will be just bearing on the heel piece of the rocker arm and the points should be just separating. If they are fully open the timing is too far advanced for the required setting, and the distributor must be rotated forwards slightly, i.e., in the direction of rotation of the cam. Move it backwards to advance.

As it is almost impossible to see precisely when the points open, a test lamp or an ammeter should be wired in the ignition circuit at the distributor "C.B." terminal. That is, the lamp or ammeter is put in series with the

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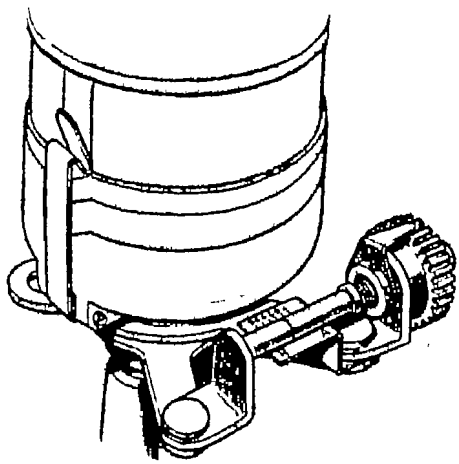
lead from the coil to the distributor. With the ignition switch "on" the lamp will light or the ammeter will show a reading so long as the points are closed. The instant that they separate, however, the lamp will go out or the meter hand will drop back to zero. That is the moment of ignition.



The Lucas micrometer adjustment for coil ignition setting. It provides two degrees advance and eight degrees retard.

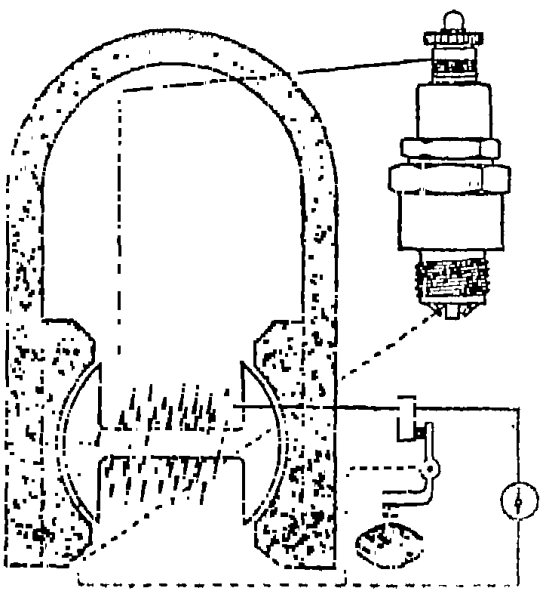
Micrometer Adjustment.

As only a very slight angular movement is necessary when setting the timing, the Lucas concern provides a micrometer adjuster. It is mounted just beneath the distributor head, and by means of a knurled knob the head may be slightly rotated. A scale having divisions equivalent to two distributor degrees traverses a mark on the micrometer spindle, thus providing a precise indication of the amount of advance or retard being given. Assuming the distributor to be set normally so that the scale reading is at zero, a range of 8 degrees retard and 2 degrees advance is provided. This adjustment, of course, is independent of the automatic control.

CHAPTER IV.

Magnetos.

A MAGNETO being a form of dynamo, no external current is required for its working; that is, it is in no way connected to the battery. We have seen how a wire moving within the field of an electro-magnet will generate electricity. By the same principle a "coil" similar in construction to that used in battery ignition can be energized by an electro-magnet.



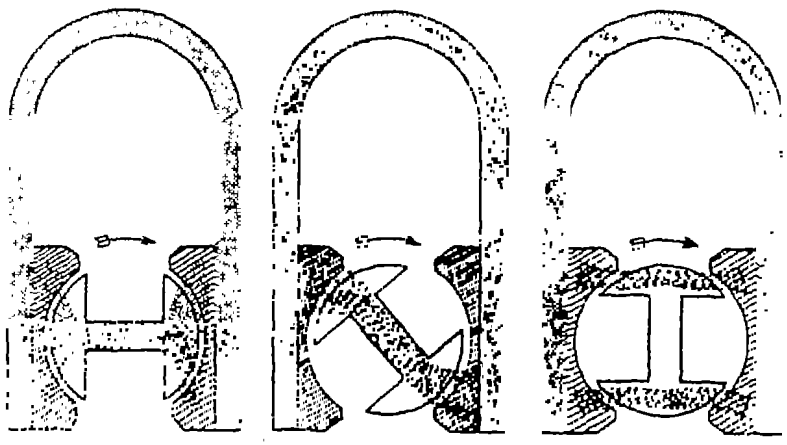
Armature windings and circuit of a normal magneto. The dotted lines indicate "earth."

In the more common type of magneto an armature of H section is wound with primary and secondary coils. The armature is built up from soft iron laminations, and is mounted on a spindle so that it can rotate within the magnetic field. One end of the spindle has a coupling which takes the drive from the engine, whilst on the other is mounted the contact breaker.

The condenser is carried in a casing behind the contact breaker and the whole assembly rotates as a single unit. Surrounding the contact breaker is a cam ring, so called because it carries two fixed cams against which the heel piece of the contact-breaker bell-crank bears during rotation.

Internal Connections.

By this means there are two "breaks" per revolution of the armature, and thus two sparks are produced. One end of the secondary winding on the armature is led out to a slip ring carried on the spindle. It is heavily insulated by means of ebonite flanges, and has bearing upon it a spring-loaded carbon brush.



The rotating armature of a magneto affects the magnetic lines of force as indicated from left to right above. It is the distortion of the field which causes the primary current to be induced in the armature windings.

The primary connection to the contact breaker is made through its centre binding screw, the head of which fits a tapered hole in the metal block which carries one of the contact points. This block is insulated from the plate upon which the rocker arm is mounted, thus the primary current flows only when the contacts are closed.

To ensure proper earthing of the contact-breaker plate a carbon brush is fitted in a boss on its reverse side, and arranged to bear upon a circular track on the

cover in which the armature ball bearing at that end is mounted.

The high-tension collector brush conveys the current from the slip ring via another brush to the distributor arm or rotor. This is driven by gearing from the armature. An insulated casing which covers the distributor arm has formed in it the electrodes whence the H.T. current is conveyed to the plugs.

Nowadays, the jump-spark type of distributor, as in coil ignition, is generally used, but there is another arrangement whereby a spring-loaded carbon brush in the distributor arm bears upon bronze segments let into the cover. Thus, the current goes direct to the plugs without first jumping a spark gap.

The Safety Gap.

Another point in the general construction of a magneto is the provision of a safety gap by which the H.T. current can escape to earth should the resistance in its normal path to the plug become too high. If no escape be provided there is a risk of the armature windings being submitted to a severe electrical strain under which the insulation might break down.

The safety gap is carried, as a rule, on the holder of the main collector brush, and no attempt must ever be made to alter the size of the gap.

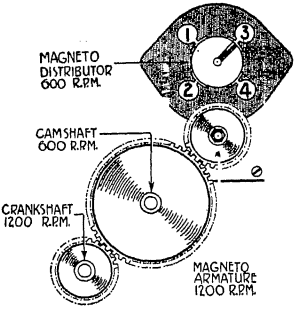
As a magneto generates H.T. current all the time it is running, means must be provided for stopping the current when it is desired to stop the engine. This is done very simply by earthing the primary current via the contact-breaker binding screw.

Carried in the insulated cover which fits over the end face of the cam ring is a light spring having a metal or carbon pad, which bears upon the head of the binding screw. The spring is connected to a terminal from which a wire leads to an earthed switch on the facia board of the car. When the switch is " open " the magneto will produce H.T. current, but " closing " the switch results

in the low tension or primary current going to earth, thus there is no induced secondary.

Speeds of Rotation.

We must now consider speeds of rotation relative to the engine. As, in the type of magneto with which we are dealing, there are but two sparks per armature revolution, it is obvious that on a four-cylinder engine the



Gearing and timing of a four-cylinder magneto. The armature runs at crankshaft speed and the distributor at half speed. Note the 1, 3, 4, 2 firing order.

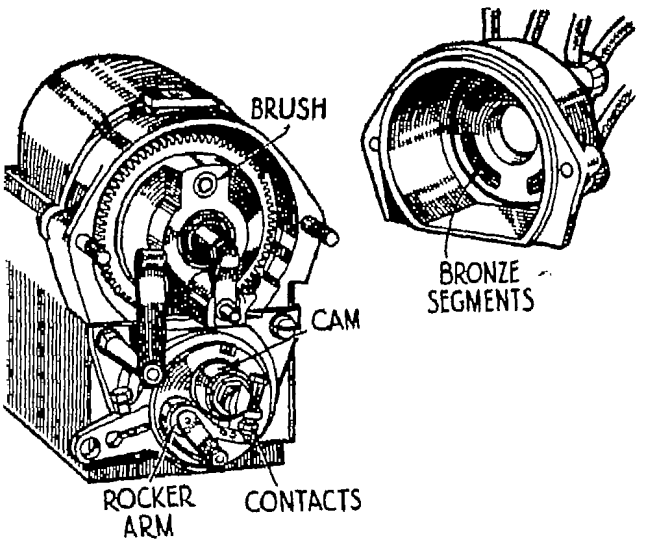
armature must run at crankshaft speed, because each cylinder needs a spark every second revolution, that is, every other piston stroke.

The same requirements exist in engines having six, eight or twelve cylinders. Therefore, in these, the armature speeds must be arranged accordingly. In a six-cylinder engine the armature rotates at one and a half times engine speed, at twice engine speed when there are eight cylinders and at three times engine speed in a "twelve."

In all cases, however, the distributor must rotate at half engine speed, therefore, it is geared down from the armature accordingly; that is, 2 to 1 on a four-cylinder magneto, 3 to 1 on a "six," and so on. The relationship between positions of the contact breaker and the distributor rotor is, of course, set by correct meshing of the gear teeth and must never be altered.

Special Types of Magneto.

The revolving-armature type of magneto is giving place to other types in which the windings are stationary. When engine speeds remained comparatively low a revolving armature proved quite satisfactory, but very



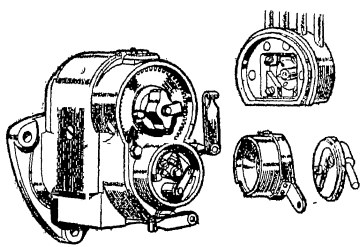
A Lucas rotary-cam magneto. The H.T. brush makes contact with the bronze segments of the distributor.

high speeds impose a great mechanical strain upon the windings as the centrifugal force generated tends to tear them from the armature.

Another trouble is that a revolving contact breaker must, essentially, be of somewhat limited size. This imposes restrictions upon its design; furthermore, it is apt to be affected by centrifugal force in a manner which prevents precise opening and closing of the contacts.

These drawbacks are avoided by the use of a p inductor magneto in which the windings are mou under the "arch" of the permanent magnet. A iron rotor of special shape revolves between the ma poles and is geared to the distributor in the ordi way. One end of the rotor spindle carries a cam wl operates a fixed contact breaker, just as in a coil tributor.

Another type of stationary armature magneto h revolving magnet. It offers many advantages w



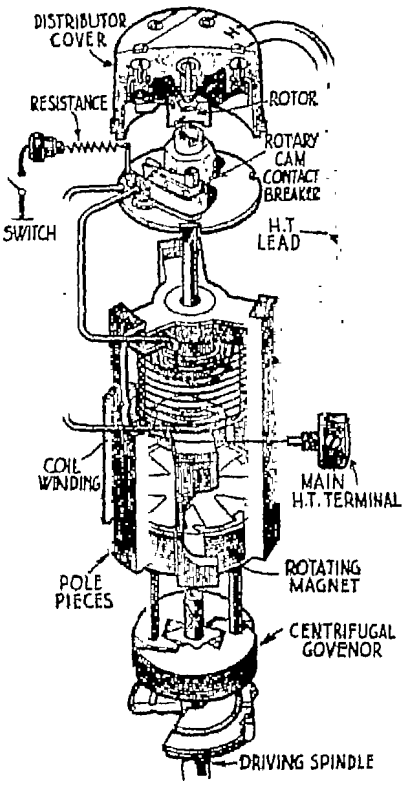
This flange-mounted magneto has a jump-spark distributor similar to that used with coil ignition.

compared with either of the types just described. Fix windings, condenser and cam-operated contact breal are used and the revolving magnet drives the dist butor by gearing. The general appearance is similar other types of magneto, but the working principle resu in a very high efficiency and a reduction in weight.

Coil-replacement Units.

A new and very interesting type of rotating magr machine has been introduced in recent years. Design to replace coil ignition on any engine, without mechar cal alteration, it runs at half engine speed and has gear-driven distributor.

The Scintilla Vertex magneto is a machine of this type. It has a cylindrical moulded casing in which pole shoes of special formation are housed. The rotating cobalt-steel magnet has poles of alternate polarity and weighs only 12 oz. Beneath it is the automatic advance mechanism, whilst the stationary armature is fitted towards the top of the casing.



A "skeleton" view of the Scintilla Vertex magneto, showing the arrangement of the various parts.

This part of the instrument is sealed, but a cover forming the distributor head may be detached to gain access to the contact breaker, which is operated by a multi-lobe cam on the main-drive spindle.

Contact-breaker adjustment is on the sliding-plate principle, and it is interesting to note that the contact points are of platinum-iridium alloy. Another notable feature is the provision of a resistance between the

switch terminal and the primary winding. This obviates the possibility of demagnetizing the magnet should a current from the car battery be accidentally passed to the magneto.

In a similar coil-replacement unit made by B.T.H., the armature windings are carried on the side of the main housing. This has within it a cobalt-steel rotating magnet and an automatic timing device. The contact-breaker assembly is mounted at the top of the housing, where it is readily accessible.

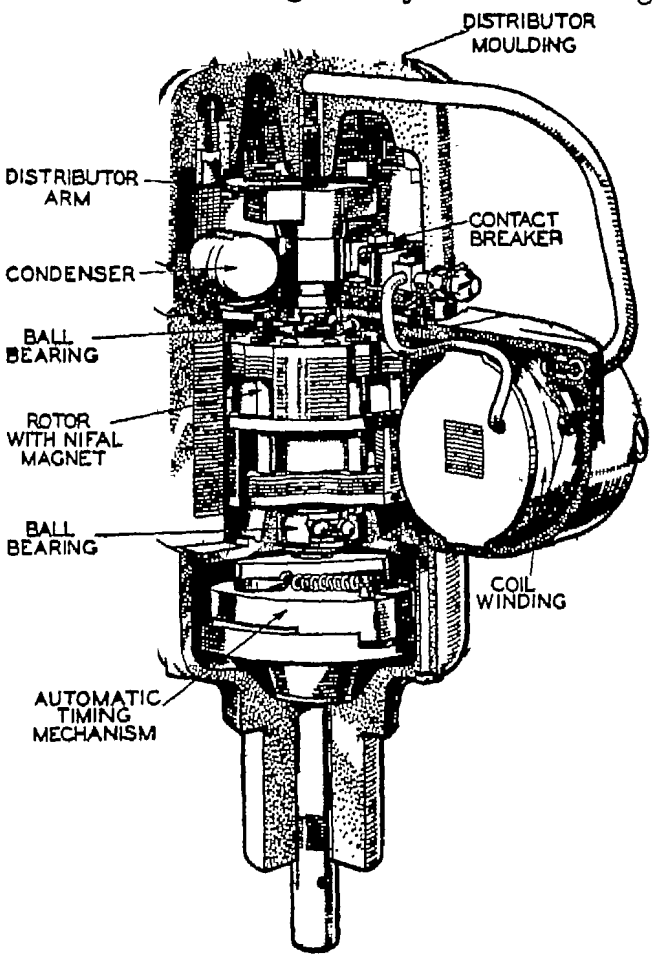
By arranging the windings as indicated the overall height of the instrument is conveniently limited; furthermore, the armature may be removed as a unit should

The B.T.H. camshaft-speed magneto has an external coil winding and a relatively small overall height.

repairs become necessary. Platinum-iridium contacts are used and the governor mechanism runs in an oil bath.

The Lucas concern also makes a coil-replacement magneto. It incorporates a magnet made of Nifal, which is a special nickel aluminium iron alloy developed by Lucas. The standard type of coil-ignition contact breaker and distributor is used, whilst the coil windings are carried on the side of the main casing.

A special feature of the automatic timing-control mechanism is that by the use of auxiliary weights coupled to the main weights any desired timing curve



Details of the Lucas coil-replacement magneto. The coil winding is a separate unit.

can be obtained. The magneto, which, of course, runs at half engine speed, works efficiently up to 10,000 engine r.p.m.

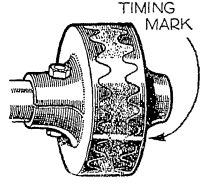
Magneto Maintenance.

Magnetos require very little maintenance attention. In the normal type it is, as a rule, the carbon brushes which cause faulty working. They are bound to wear away slightly in use and the carbon dust thereby

produced may be deposited on adjacent surfaces and can lead to an appreciable current leakage to earth.

In wipe-contact distributors it is possible—but not very probable—for a complete track of carbon dust to be formed so that H.T. current can find its way to all plugs at the same time—a state of affairs which would lead to somewhat peculiar running!

A petrol-damped rag is all that is necessary to remove the carbon dust from a distributor brush track, but it is worth while, sometimes, to clean the segments with liquid metal polish. If the brush track be very uneven owing to the segments having burnt, it is a good plan to take the distributor cover to a garage and have the



By marking the three parts of a Vernier coupling with a streak of paint correct reassembly is assured. A coupling of this kind allows a timing variation of less than one degree.

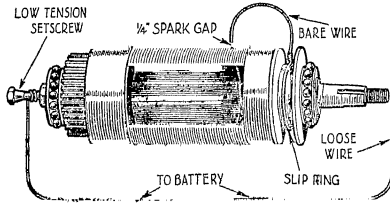
track trued up by turning or grinding. This will result, of course, in its being slightly over-size, but the increase in diameter will have no effect upon the rotating carbon brush.

If the brush be in good condition its working face will be polished and slightly curved. There is no point in filing the face unless it be chipped badly; similarly it is not a good plan to increase the spring strength in an effort to secure improved contact.

This remark applies also to the other brushes; only the lightest spring pressure is necessary and any increase will merely bring about excessive brush wear.

Armature Removal Precautions.

If the armature is to be removed for cleaning purposes care must be taken first of all to see that the teeth of the distributor gears are marked for correct re-meshing. The contact breaker and the high tension collector brush must be removed before sliding out the armature; it is generally more convenient to remove this from the driving end of the machine as it is not then necessary to take off the coupling, which will be a tight fit on the tapered end of the armature spindle.



A simple armature test. With a battery in circuit a spark should jump the gap when the loose wire is "flicked" against the end of the spindle.

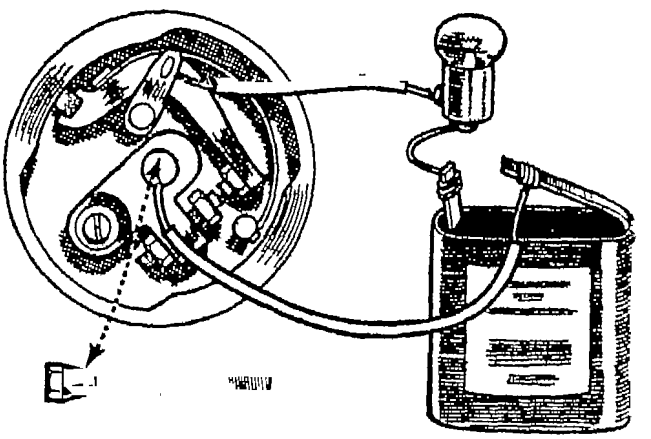
The instant that the armature is withdrawn from its tunnel a keeper must be slipped across the pole shoes, otherwise there will be a loss of magnetism. The keeper must remain in position so long as the armature is out. Any fairly heavy piece of iron or steel will serve as a keeper, but it should have flat faces so as to make proper contact.

An armature must never be washed in petrol because of the risk of dissolving the insulating varnish. Careful wiping with a rag should be all that is necessary, but if there is rust on the laminations or on the pole shoes this can be removed by gently rubbing with glass paper.

Rust sometimes forms owing to the presence of moisture in the armature tunnel and as the clearance between the armature and the pole shoes is only a few thousandths of an inch the presence of rust may prove harmful. When refitting the armature great care must be taken to see that the bearings are properly in place and the end plate tightened fully home.

The Contact-breaker Gap.

The contact breaker should have a gap of about .012 in. and this should be equal for both cams. When checking the gap make sure that the cam ring, if



By connecting a flashlamp bulb and battery as indicated exact timing is easy. The lamp will go out the instant the contacts are opened by the cam.

it be of the movable type, is properly in place on its spigot, because if it be twisted slightly, as may easily happen, it may affect the gap setting.

In some types of magneto the contact points are made of tungsten. This is a very hard metal that cannot be filed; therefore, when truing the points it is necessary to use a carborundum slip, obtainable from most garages. The truing should be done before the gap is adjusted so that an exact setting can be made. The points must come together squarely, as it is bad practice to let them touch only on one side. Very

badly pitted points sometimes indicate a faulty condenser, but this, of course, cannot be made good by an amateur.

Remagnetizing.

Whatever type the magneto may be, reduced sparking efficiency can often be traced to loss of magnetism; that is, to the magnets becoming weak. Full strength can be restored by remagnetizing and all electrical service stations are equipped with the necessary plant. The magneto must, of course, be removed from the engine to be remagnetized but it is not always necessary to dismantle it, the complete machine being mounted on the magnetizing apparatus and only a few seconds are necessary for doing the job.

Magnets have somewhat peculiar properties and it should be borne in mind that all magnetism can be lost if they receive a sudden blow or if they become unduly hot.

The maintenance and adjustment hints given in this chapter are applicable to all types of magneto, but before doing anything beyond cleaning, the magneto maker's own instruction book should be consulted. There may be an important part which requires special treatment.

CHAPTER V.

Sparking Plugs.

MUCH careful thought has been devoted in recent years to the design of sparking plugs. Increasing cylinder pressures, internal temperatures and engine speeds impose stresses which are not easily resisted.

Practically all plugs are of the same general construction. There are two main parts—a steel body, which screws into the cylinder, and an insulated centre piece carrying a rod or electrode. This is arranged in such a manner that there is a small air gap between it and the earthed body, and it is across this gap that the spark jumps.

It is usual for the centre piece to screw into the body so that it is readily detachable for cleaning purposes. The insulation may be of mica, steatite or porcelain. Efficient heat-resisting properties are essential and the material must also be mechanically strong.

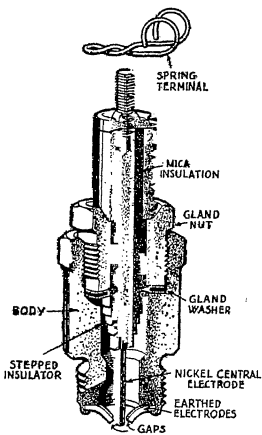
Electrode Metal.

The central electrode is usually of nickel alloy, but sometimes other metals are used, according to special requirements. Resistance to oxidation and burning are essential features, but, in addition, sparking efficiency is governed largely by the electrode metal.

Some plugs have three earthed electrodes or "points," whilst others have only one; again, there are plugs in which an earthed ring is formed around the central electrode so that the spark jumps the annular gap.

Plug makers have been at pains to provide a wide selection so that all engine conditions can be met, and they issue charts showing their recommendations.

Thus the correct choice of a plug is easy. There is seldom anything to be gained by departing from the recommendations. Racing plugs, for instance, will not add speed to a touring engine; similarly, a touring plug will probably burn out very quickly in a racing engine.



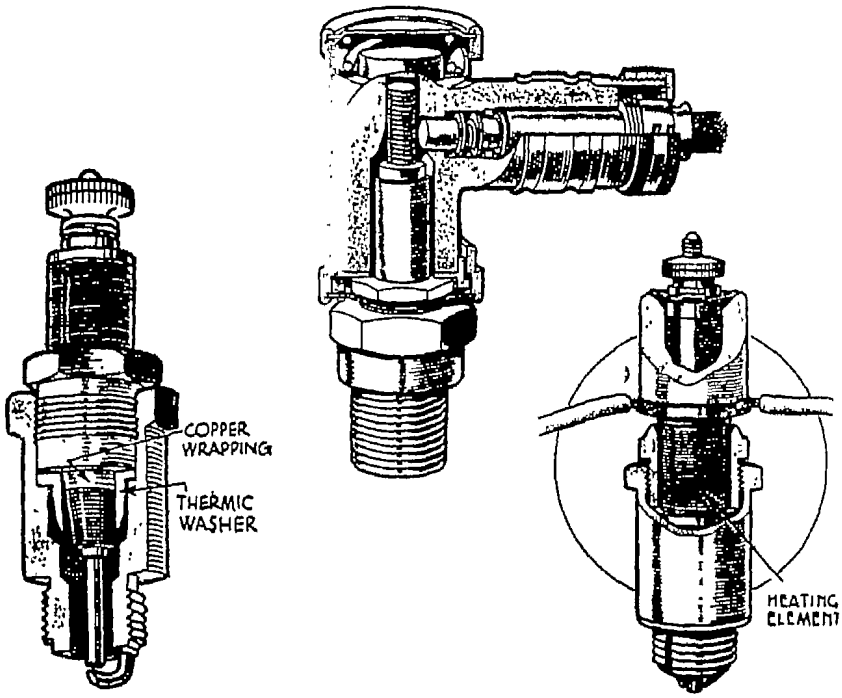
This section of a standard K.L.G. plug shows clearly the general construction.

Cheap plugs are seldom worth buying; they may be electrically unsound and have electrodes of unsuitable metal. Mechanical failure, whereby the electrodes fall into the cylinder and cause considerable damage, is by no means unknown.

The standard type of plug used in British and Continental cars has a metric thread of 18 mm. diameter with

a pitch of 1.5 mm. The depth of the thread is either ½ in. or ¾ in., according to whether the plug is of the short-reach or long-reach type.

A smaller type of plug having a 14 mm. thread is now in fairly general use. It was introduced originally to overcome the difficulty of providing sufficient room for



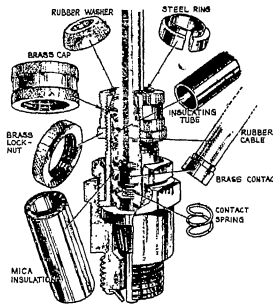
These three plugs are (left) the Massa, which has a heat insulating thermic washer or thimble around the inner mica; (centre) a Lodge plug specially shielded for use on cars fitted with radio, and (right) the Cooper-Stewart electrically heated plug for easy starting.

an 18 mm. plug in o.h.v. engines of special design. In addition to reduced size, the smaller amount of metal in the plug helps to keep it cool; furthermore, the boss passing through the water jacket can be made smaller, therefore additional water-cooling space is available.

A possible drawback with 14 mm. plugs is that the insulation surrounding the central electrode must be of smaller dimensions than in the 18 mm. type. Because of this, there is greater risk of electrical leakage, but the

plugs have been developed to a very high standard of efficiency, and if the correct type be used there is little risk of failure.

It may be pointed out that 14 mm. plugs are not in themselves more efficient than the 18 mm. type. They are used only for convenience in certain designs of en-



This special form of Lodge plug has been developed for use where absolute watertightness is essential.

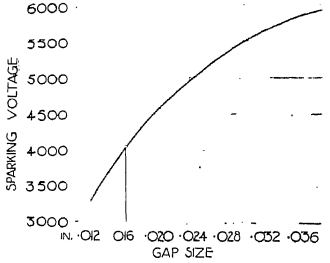
gine, and because, as already mentioned, they remove, to a certain extent, a normally uncooled portion of the cylinder head. Nothing is gained by fitting screwed liners in 18 mm. plug holes so that 14 mm. plugs may be used.

In addition to the foregoing types of plug, there is a special variety used mainly in the engines of American cars. They are similar in their general construction, but they have a $\frac{3}{8}$-in. taper A.L.A.M. thread; they therefore tighten with a kind of jamming action in the cylinder head, and do not require a copper asbestos washer. Where it is desired to use standard metric-thread plugs on American engines, special screwed adapters are obtainable.

Provided that the correct type of plug for any give engine be chosen, it makes little difference whether it ha one or three points. Some people believe that with three-point plug a spark occurs at all three gaps at th same time, thus improving firing efficiency. This is fallacy. The spark jumps only one of the gaps, choos ing that which offers the least resistance at the particula instant when the discharge occurs.

Theory of Spark Discharge.

There are, as it were, two stages in the formation o the spark, but together they occupy only so infinitesima a fraction of a second that they may be regarded a occurring simultaneously. Let us see exactly wha happens.



The effect of gap size upon sparking voltage. This graph was developed by the makers of A.C. plugs.

For all practical purposes a gas is an insulator, that is to say, a non-conductor of electricity, but by a process known as ionization it can become a conductor. Ions are molecules changed from their neutral state, and they may be positive or negative, according to whether they have lost an electron in the process or gained one.

These phenomena are, of course, connected with the electronic theory of matter and do not particularly concern us here. We must know, however, that under the influence of an electric field such as will exist at the plug points at the moment of discharge, the electrons and ions will be busily rearranging themselves, and a condition will arise when the ions will bridge the gap between the two electrodes and the spark will pass.

With a three-point plug ionization occurs at all three gaps, but the formation of the bridge of ions may be more rapid at one gap than at the other two, therefore the spark will pass across the bridge which is first formed.

In a single-point plug ionization occurs in just the same way, but with either type the shape and size of the electrodes has a very great influence on sparking efficiency; so, also, has the size of the gap.

Various Plug Faults.

No matter what type of plug be used there will be no spark if carbon forms on the points and bridges the gap. It is easy to see why this should be so with a single-point plug, and a little thought will show that if one gap of a three-point plug be "shorted" the current will pass across to earth rather than jump one of the remaining gaps.

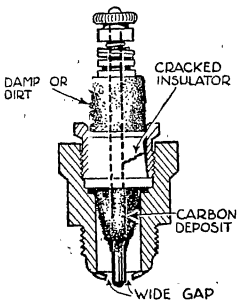
A coating of soot, carbon or oil on the insulation inside the plug body may also give rise to misfiring by allowing the current to leak over the coating to earth. The leakage can be direct or, possibly, the current will spark across, but, owing to the pocketing effect of the plug body it is unlikely that the spark will fire the mixture.

Some types of plug are provided with stepped or skirted insulators. The effect of this may be twofold; the irregular surface does not lend itself readily to the formation of carbon deposits, whilst, furthermore, the stepping or skirting increases the length of the path along which the current must travel from the electrode to the body. The chances are, therefore, that unless the

plug be badly fouled the ionized gap will offer a lowe resistance to the current than that presented by tortuou insulator paths. Hence misfiring is avoided.

Plug-cleaning Precautions.

When cleaning plugs it is very important to avoi scratching the insulation material. When the centr part is detached from the body the insulator can b wiped with a petrol-damped rag. Judicious scraping is perhaps, allowable in bad cases, but care must be taker



Causes of plug failure. Any of the faults indicated may give rise to misfiring or complete breakdown.

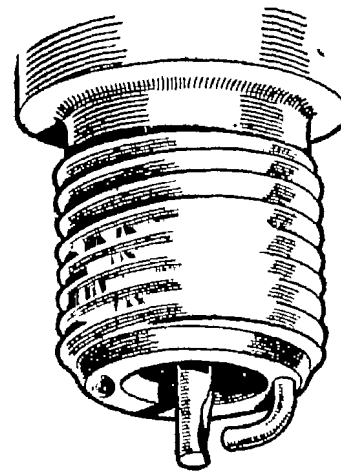
with mica insulators to avoid flaking. A smooth and polished surface is the finish at which to aim.

Scratched insulators are not necessarily impaired electrically, but the rough surface encourages the formation of carbon deposits by enabling them to key on readily.

The electrode itself may be rubbed with very fine glass paper, but remember that, being made of fairly soft metal, it is easily bent. No attempt should ever be made to alter its shape by filing.

A stiff wire brush can be recommended for cleaning the end of the plug body and the attached electrodes. These, like the central electrode, should never be filed.

When reassembling a plug, see that the seating within the body against which the flange on the centre part abuts, is clean and free from grit. As a rule, a plain copper washer is interposed between the seating and the flange ; this must be in good condition.



After long use the central electrode of a plug tends to burn away, thus increasing the gap.

The gland nut should be tightened down fully, preferably by the use of a box spanner, so that risk of distortion is avoided.

Naturally, the upper part of the insulation between the terminal and the body must be clean. If it be cracked or, in the case of mica, distorted, there is considerable risk of current leakage ; in fact, the plug will probably have to be discarded.

Setting the Gap.

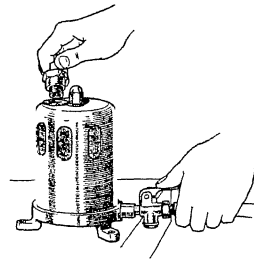
The final job after cleaning a plug is to set the gap or gaps. A feeler gauge should be used, as an exact setting cannot be obtained by guessing.

As a general rule, a gap of .02 in.—or .5 mm.—is correct for all normal plugs with either coil or magneto ignition apparatus. A variation from this setting,

however, is to be found, to mention only one instanc in the case of Delco-Remy equipment, where a gap .028 in. to .030 in. is recommended.

It will be clear, therefore, that there is no hard-an fast rule, but it may be said that the limits should l between .015 in. and .030 in. Very small or very lar gaps lead to misfiring. A small spark may fail to igni a coarse or "lumpy" mixture, whilst if the gap be u duly large the sparking voltage required to jump it ma be so high that the current will prefer to leak across th insulator.

Before leaving the question of plug cleaning an setting it may be mentioned that owners who do nc care to clean their own plugs may have the work don



A B.E.N. plug cleaner for service station use. It is worked by compressed air.

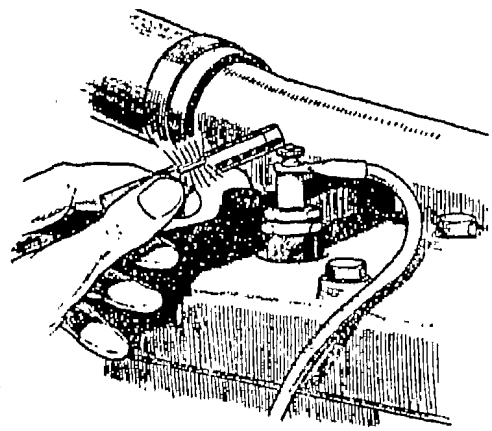
very efficiently and inexpensively at a garage, where, as a rule, a plug-cleaning machine will be installed. The service usually includes re-setting of the gaps and, in some cases, the plugs are tested under pressure.

Cold-starting Troubles.

When an engine is first started from cold in very damp weather, sparks can often be seen or heard jumping from the H.T. terminal to the body of a plug. This is

because the insulator has on it a very thin coating of moisture down which the current leaks in preference to jumping the gap at the points.

A cold plug requires a much higher sparking voltage than a hot one, owing to the fact that at low temperatures the electron emission at the gap is reduced. If, therefore, no bridge of ions be formed over which the spark can pass the current will find an easier path, and this may well be across the damp insulator.



A neon plug tester in use. Its indications are a useful guide to sparking efficiency.

A warm rag will prove effective for wiping the insulators dry, but in cases of really obstinate starting a good plan is to remove the plugs from the engine and to heat them on a gas ring or before a fire. If, then, they be replaced in the engine before they have time to cool the effect will be twofold. The moisture will have been evaporated and the electrodes will have attained a temperature at which there will be efficient ionization at the gap.

Where obstinate starting is due to spark inefficiency, such as might be caused by a weak magneto, or a partially discharged battery in the case of coil ignition, it is advisable to see that the plugs are perfectly clean, especially with regard to the internal insulated portions, and that the points are set as closely as possible. It will

sometimes be found that rubbing the electrodes with lead pencil will aid "cold" sparking.

When doubt exists regarding the condition of a plu no accurate idea of its efficiency can be obtained l removing it from the engine and watching it spark whil lying on the cylinder head. In these circumstances, tl plug is not working under normal conditions, and if spark occurs regularly at the points it by no means fc lows that it will do so when the plug is in the engine ar subjected to the compression pressure.

It makes no difference whether the fault lies in tl plug or in the coil or magneto. No true idea of pe formance can be gained by testing under atmospher pressure. Most garages and service stations ha special appliances whereby the plugs can be tested und high pressure, thus all doubt regarding their efficienc can be removed.

Neon-tube Testers.

A very good idea of how a plug is behaving in th cylinder can be gained by the use of a neon teste This consists of an insulated holder in which is inserte a sealed glass tube containing neon gas. The tube connected at one end to a piece of metal, which ma take the form of a cap on the end of the insulated holde

In use, the tester is brought against each plug in tur so that the metal part touches the plug terminal. Th test is made, of course, with the engine running, and if plug is sparking properly there will be a series of brigl flashes in the neon tube, whilst faulty sparking is ind cated by the dullness or irregularity of the flashes.

A neon tester is useful also in tracing leakage of high tension current along the cables connecting the plugs t the distributor. The tube will glow when brought nea the cables, even when the insulation is perfectly gooc but if the rubber be cracked or perished the glow at tha point will be very much brighter.

CHAPTER VI.

Dynamos.

THE general principle upon which a dynamo works was described in Chapter II. At this point, therefore, we can turn directly to a consideration of the type of machine used on cars. It is of very simple construction, as there is only one rotating part, called the armature, and, of course, no timing mechanism is necessary.

As a rule, the casing is of cylindrical shape and contains the field magnets which have pole shoes shaped to embrace the armature which is mounted centrally within the casing and carried in bearings at each end. One of the covers in which the bearings are fitted also carries the brush holders, and these, in turn, are provided with carbon brushes that bear on the commutator fixed on the armature shaft.

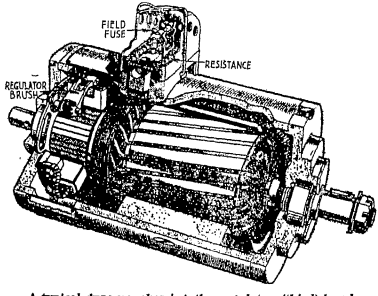
The armature itself consists of a large number of soft-iron stampings assembled in a compact mass, and afterwards machined to an exact diameter. Each stamping is slotted in such a manner that, when assembled on the shaft, the slots form longitudinal grooves, and in these are wound coils of insulated wire connected at their ends to the bars of the commutator.

There are various methods of arranging the windings, whilst quite often the slots are not parallel with the axis of the armature shaft, but are given a kind of twist. This is done for a reason which need not concern us here. It is important, of course, that the windings shall be fixed rigidly in place to resist the effect of centrifugal force when the armature is rotating at a high speed; furthermore, the armature must be balanced so that it runs without vibration, as the clearance between it and the

surrounding pole pieces is very small—only a few thousandths of an inch. This clearance is known as the air gap.

Types of Dynamo.

There are often four field magnets in the normal type of dynamo, but it is practicable to use only two magnets, or even one. The windings on each pole are



A typical dynamo, showing the regulator (third) brush, resistance housing, armature and field windings.

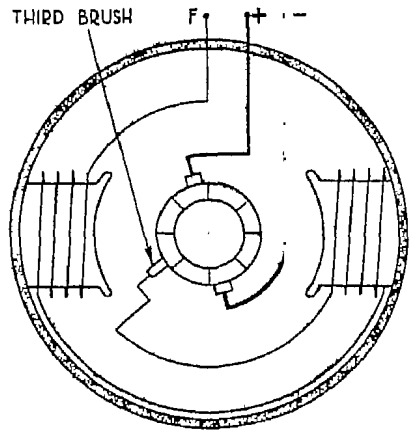
joined together whilst the two ends are led out and connected to the brush gear. There are three types of dynamo, known as series, shunt and compound wound. The shunt type is that almost invariably used on cars, as it has the advantage of building up quickly to its full output, whilst it is, to a certain extent, self-regulating. In a normal type of shunt-wound dynamo there will be two brushes bearing on the commutator, and to each will be connected one end of the field windings, whilst the external circuit will also be connected to the brushes.

For use on cars, however, a dynamo of this type is not entirely suitable owing to the considerable speed

variations to which it is subjected, the self-regulating properties of the machine being insufficient to keep the voltage reasonably constant when the armature speed may vary from, say, 1,000 r.p.m. to 4,000 r.p.m., or even more.

Regulating the Output.

A very simple method of providing accurate control of the voltage consists in adding another brush and arranging the connections so that the additional brush is wired to one end of the field winding. The other end of the winding is joined to a main brush, from which leads a connection to a terminal on the dynamo casing or end cover. The second main brush is also connected to an external terminal.



This diagram indicates the connections in a third-brush dynamo of average type.

The third brush governs the output by progressively weakening the magnetic field as the speed rises. Variations in output can be made on most dynamos by altering the position of the third brush, which is mounted in a movable holder. Moving the brush forward slightly, i.e., in the direction of armature rotation, increases the current. On some dynamos, however, the brush is moved backwards to increase the output. The ammeter should, therefore, be watched closely when the adjustment is being made.

Great care must be taken when resetting the brush to see that the new position does not cause excessive sparking at the commutator. The job is, in fact, not one which amateurs can be recommended to undertake; it should be entrusted to an electrical service station.

Third-brush Setting.

Where, however, this course be impossible, a fairly safe method is to proceed as follows:—

With the engine and, therefore, the dynamo at normal running temperature open the throttle, with the gear in neutral, to a point where the engine revs. represent about 30 m.p.h. The dynamo should then be generating its full output. If it is not, open the throttle a little more.

Switch on all the lights—head, side and tail—and note the reading of the ammeter; it should show a small amount of charge—about 2 amps., or a little less. If the needle is on the discharge side of zero move the third (regulating) brush of the dynamo, as required, to obtain 2 amps. charge. Alternatively, if a charge of rather more than 2 amps. is shown in this test the output must be reduced as it will be too great when the lamp load is removed.

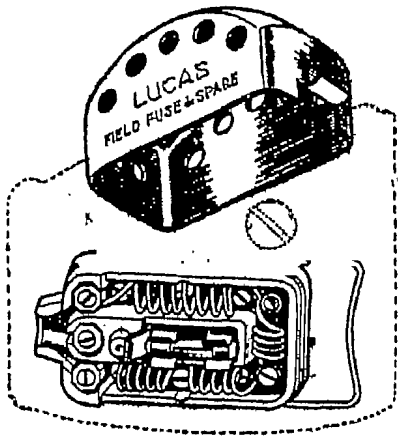
It is assumed, of course, that bulbs of standard wattage are used. If "oversize" headlamp bulbs be fitted—taking, say, 2 amps. more than normal—one should be content with a zero ammeter reading on full load, i.e., no "charge" and no "discharge," otherwise during daylight running the battery will receive an excess charge.

The method of arranging for brush movement varies with different dynamos. Sometimes there is a locking screw (or two screws) working in a curved slot in the end cover. The brush can be moved after slacking the screw (or screws) very slightly.

In another design part of the brush carrier is formed as a toothed segment with which meshes a small pinion. A hexagon on the pinion enables it to be rotated with a spanner, thus moving the brush. A locking screw in

the end cover prevents movement at the wrong time. There is a further scheme in which the brush carrier is frictionally held, so that only a fairly hard push is needed to move the brush.

On some types of dynamo the current can be further regulated by means of a hand-operated switch, which introduces resistances into the circuit. As a rule there are two switch positions, "charge" and "half-charge." In the "charge" position the normal output of the dynamo is allowed to pass; for "half-charge" the amperage is reduced to approximately half the full rate.



Arrangement of the field fuse and charging resistances on certain types of Lucas dynamo.

An additional resistance, which remains in circuit until the lights are switched on, may also be provided. By this means an excessive "daylight" charge is avoided, but the output is boosted up when the lamp load comes on.

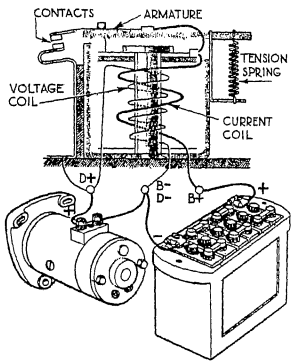
The Field-circuit Fuse.

In spite of third-brush governing, a voltage beyond the safety limit may be generated in certain circumstances; its effect would be to burn out the field coils. To guard against this, a fuse is provided in the field circuit. On modern cars there are fuses also in the lamp circuits, but these have no direct effect upon the dynamo.

The field fuse will blow only if a fault develops in the main circuit, and it is a mistake merely to replace the

fuse without finding the cause of its blowing. It is an even greater mistake to substitute a heavier-gauge fuse wire to prevent blowing. A fuse is a safety valve set to blow at a certain pressure, and any attempt to increase the "strength" of the fuse may lead to trouble.

If a dynamo and a battery be connected together and the dynamo be stationary, or running below its charging



A normal type of cut-out, showing the various connections to the dynamo and the battery.

speed, the battery will feed back through the dynamo. This, of course, will result in the battery being discharged; therefore, a switch must be placed in the circuit so that the current can be cut off whenever the dynamo is not generating.

Continuously to operate the switch by hand would be troublesome and uncertain, but it is quite easy to provide an automatic switch worked by the battery and the dynamo.

The Automatic Cut-out.

Practically all cars have a switch of this kind, and it is known as a cut-out. Its construction and working are very simple. A soft-iron core carries two windings. One, the voltage coil, is of fine wire with its ends connected across the dynamo terminals, whilst the other, of thicker wire and known as the current coil, may have one end connected to the positive battery terminal. The other end is led out to a hinged soft-iron armature, which passes across the top of the core and carries a contact on its free end.

The opposite, or fixed, contact is mounted on—but insulated from—the cut-out frame and connected to the positive dynamo terminal. A tension spring holds the contacts apart when no current is flowing in the coils.

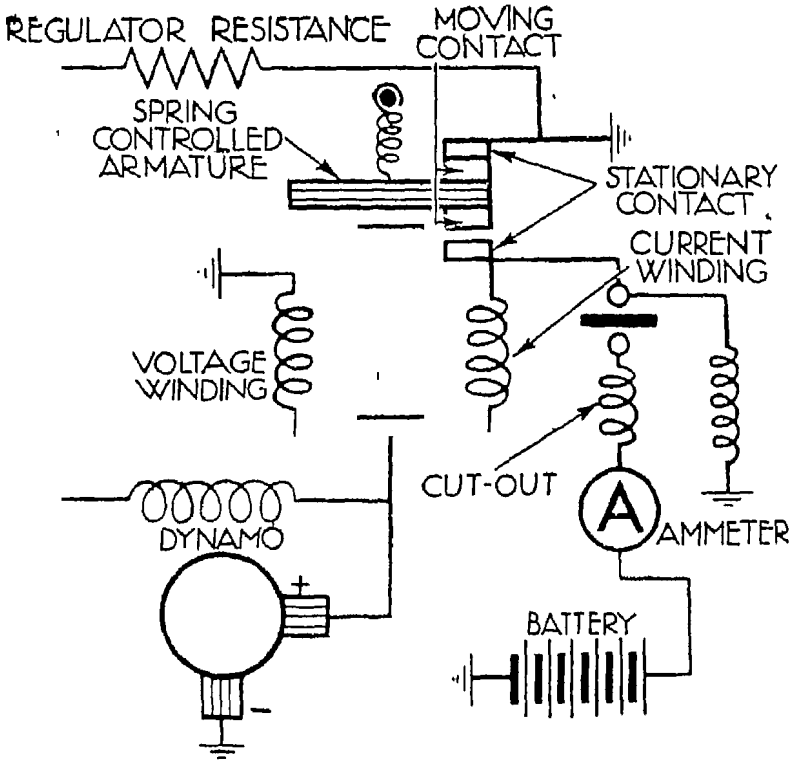
The action of the cut-out is as follows:—When the dynamo is working a current flows through the voltage coil and magnetizes the core. The magnetic pull attracts the armature, causing it to overcome the tension of the spring; thus the contacts close and allow the dynamo current to pass to the battery via the current coil. This increases the magnetic pull on the armature, so that the contacts are firmly pressed together, thus providing a free path for the current.

So long as the dynamo is running at charging speed the contacts remain closed, but when the voltage falls below that of the battery, as when the dynamo begins to slow down, the current reverses, passing from the battery to the dynamo. Thus there are two opposing currents acting on the cut-out windings, and their effect is to demagnetize the core. This allows the armature to spring up so that the contacts open and stop the flow of current from the battery.

Cut-out Adjustments.

The contact adjustment must be very accurately set if the cut-out is to work properly. Generally, the contacts close when the current reaches about .5 amp. and open when a reverse current of similar value passes.

It is not advisable, as a rule, for amateurs to interfere with the mechanism of a cut-out, and for this reason the instrument is nearly always protected by a sealed cover. Faults which can develop in a cut-out may consist of burnt-out windings, burnt or pitted contacts, or a sticking armature, due to the pull-off spring having weakened.



Wiring diagram of the Lucas voltage regulator with which a two-brush dynamo is used.

If the cut-out cover is not sealed, or if one cares to break the seal (thereby possibly invalidating the guarantee), minor defects can often be made good by the exercise of a little skill and care.

Burnt contacts can be trimmed by the use of a contact file rubbed between them whilst the armature is pressed down gently. After trimming, it is necessary to see that the two points come together fully before the armature touches the cut-out core. Actually, with the points

touching there should be a gap of .015 in. or so between the armature and the core.

A word of warning is necessary here. Before touching the cut-out contacts, the battery leads should be disconnected from the terminal posts; merely turning the charging switch to "off" is not sufficient, as it breaks only the dynamo field circuit.

A weakened pull-off spring is an unlikely fault, but one not easily rectified, except by fitting a new spring obtained from the makers, as it is very difficult to find the correct tension by experiment.

In the case of burnt-out windings, a rewind is beyond the scope of most amateurs, and the makers should be consulted.

Momentary sticking of the contacts, by the way, can sometimes be overcome by jarring the casing; the fact that they have separated will be indicated by the needle of the ammeter returning to zero.

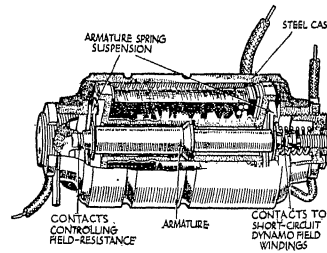
It must be understood that a cut-out is simply a safety switch which connects the battery to the dynamo for charging purposes, but it does not disconnect it when a state of full charge is reached; thus it is possible, in certain circumstances, to overcharge the battery, that is, to supply it with more current than it needs. This may result in the plates being damaged.

A battery can be maintained in perfect condition only when it receives a properly regulated charge, and this is a requirement which a dynamo of the third-brush type cannot fulfil.

Voltage-regulator Systems.

There is, however, a special form of dynamo—to be found on many modern cars—which regulates the charging current very precisely. The machine has been developed over a number of years in connection with commercial vehicles, where the demands upon the battery are particularly heavy; it may be taken, therefore, that the perfected system, now applied to private cars, is entirely satisfactory and reliable.

The dynamo is similar to a third-brush machine external appearance, but it is wound differently and t third brush is omitted. There are, in fact, only the tv main brushes—positive and negative. The output the dynamo is controlled by a regulator unit which m be housed at any convenient point on the car, such the dashboard, and has combined with it a junction b and a fuse box.



Lucas voltage-regulator unit sectioned to show the windings, armature and contacts.

The regulator causes the dynamo to give an outp which varies according to the state of charge of th battery. If the battery be discharged, the dynam gives a high output, so that a normal state of charge reached in a minimum time. If, however, the batter be fully charged, the regulator cuts down the dynam output so that only a trickle charge passes to the ba tery, just sufficient to keep it in good condition witho risk of causing damage by overcharging.

In addition to controlling the rate of charge of th battery, the regulator provides for an increased dynam output to balance the current taken by the lamps c other accessories whenever they are in use.

On most cars the regulator system is set to provide a suitable current output at a road speed of about 20 m.p.h. Thereafter, irrespective of speed, the current supplied to the battery will be in accordance with its state of charge, so that the ammeter may show a high reading just after starting from cold, and fall to only 2 or 3 amps. when the car has been running for 10 minutes or so.

There is no charging switch, as the apparatus is entirely automatic; moreover, the lamps are always supplied with their full rated voltage, and there is no risk of their being burnt out owing to a faulty battery connection.

Construction of the Regulator.

The voltage regulator consists of a cylindrical steel shell containing two windings through which passes a core or armature carried on a pair of guide springs. At each end of the core is a pair of contacts, one of which serves to insert a resistance in the field circuit, whilst the other pair short-circuits the field winding. The first pair of contacts is held closed by means of a spring when the regulator is not working.

The windings consist of a voltage coil, connected directly across the dynamo terminals, and a current coil which carries the full current from the dynamo to the battery.

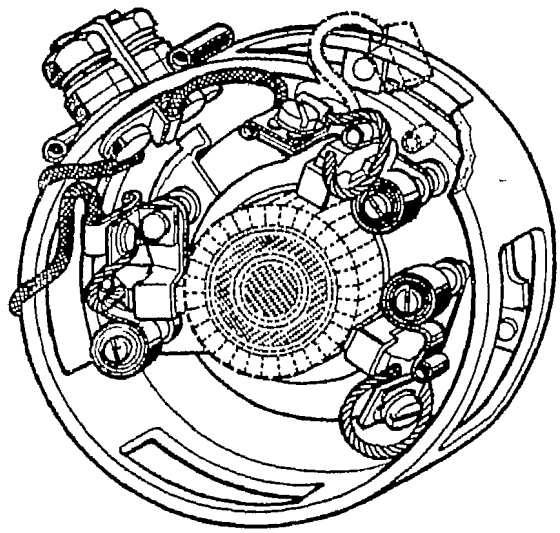
When the dynamo voltage reaches a predetermined figure the magnetic field set up by the voltage coil becomes sufficiently strong to attract the spring-mounted core. This causes the first set of contacts to open, thereby inserting the resistance in the field circuit.

The resulting reduction in field current naturally lowers the dynamo voltage, and this, in turn, weakens the magnetic field set up by the voltage coil; thus the core is allowed to return to its original position where it closes the contacts and so allows the voltage to rise to the predetermined maximum. The cycle is then repeated, and so rapid are the changes that the core is set into vibration, the amplitude increasing with the speed of the

dynamo above that at which the regulator comes int operation.

When the vibration of the core is sufficiently high, th second pair of contacts comes into operation and shor circuits the field winding of the dynamo ; thus the initi movement of the core inserts a resistance in the fiel windings, whilst additional movement short-circuits th windings entirely.

The current coil of the regulator provides a means fc compensation, as without it there would be a risk c overloading the dynamo when the battery is in a lo state of charge. The winding assists the voltage coil s that when the dynamo is delivering a heavy current int a discharge battery the regulator comes into operatic



General arrangement of the brush gear on a dynamo. The brushes, held in contact with the commutator by means of "clock" springs, are easily removed for cleaning.

at a somewhat reduced voltage and limits the dynan output accordingly.

A cut-out of the type already described in this chapt is used in conjunction with the regulator, but neith piece of apparatus requires attention from the owner the car; they are, in fact, sealed. An adjustme is, however, provided on the regulator unit so th

alterations in its controlling function can be made at a service station.

Dynamo Maintenance.

Dynamos, whether of the voltage-regulator or third-brush type, require a little maintenance attention from time to time, and this is mostly in connection with the commutator and brush gear.

After long service the armature will become blackened on its surface and, perhaps, scored slightly, whilst the mica strips which insulate each of the commutator bars or segments may tend to project slightly above the general surface. These are conditions which lead to faulty working, as the projecting micas prevent the brushes from making proper contact with the commutator bars, and this, whilst cutting down the output, will also lead to bad sparking, with consequent burning of the commutator and the brushes.

The mica strips can be cut down by careful manipulation of a suitable tool, such as a very fine hacksaw blade, but it is necessary, of course, to remove the armature from the dynamo casing in order to gain access to the commutator.

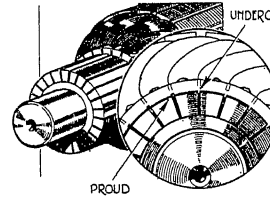
This is a job, however, which any reasonably skilful amateur can undertake. It is first necessary to remove the dynamo from the engine, bearing in mind that where a coil distributor is driven by skew gearing from the dynamo spindle retiming will be necessary upon replacement; therefore the teeth of the driving gears should be marked.

Undercutting Commutator Micas.

On the bench the armature can be withdrawn by unscrewing the cover at the driving end of the machine and pulling it clear. Care must be taken, however, first of all to withdraw the brushes from their holders, and to make sure that they cannot be replaced incorrectly. With the armature out, the commutator can be examined, and if the micas must be cut down it should be clamped gently in a vice, the jaws of which are protected by lead or fibre clamps. A very steady hand is needed

for cutting the micas, because if the cutting tool slips i will score the copper.

If a lathe is available, it is an excellent plan to moun the armature between the centres and to bolt a very narrow parting tool sideways in the tool holder, so tha when the saddle is moved along the bed the tool wil operate on the mica after the fashion of a planer.



Projecting or "proud" commutator micas prevent proper brush contact. They should be undercut slightly.

Only a slight undercut is necessary; that is to say, th mica strips should lie about 1-32 in. below the coppe surface. The bottom of the cut should be square an not V-shaped. When the cutting is finished the surfac of the commutator can be polished by use of very fin glass paper. Emery cloth should never be used, as th grains of emery may bed themselves into the commuta tor and cause rapid brush wear.

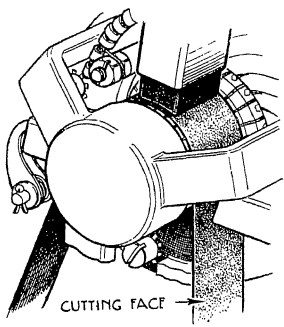
If the armature is badly pitted or burnt it may b necessary to skim it up in a lathe, but a very fine cu should be taken—only just sufficient to remove th pitting. Naturally, if this be necessary, it will be don before the micas are undercut.

Bedding-in the Brushes.

When the armature is refitted to the dynamo it wi be necessary, in all probability, to bed in the brush on the new commutator surface. Their working fac

should first be examined, and if they are bright, with fairly clean-cut edges, they will require very little attention, but chipping or pitting will indicate the need for resurfacing.

The best way to do this is to pass a strip of fine glass paper around the commutator with the cutting surface outwards. Each brush, in turn, is then slipped into its holder, with the spring pressing on it, and the glass paper pulled backwards and forwards around the radius of the commutator. This will cut the brush



Brush faces can be curved to the commutator radius by the use of a strip of glass paper arranged as indicated here and pulled to and fro.

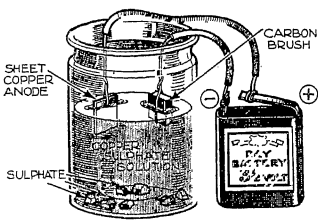
face to the correct curve, as the thickness of the glass paper may be disregarded.

When all of the brushes have been treated in this manner, a soft-haired brush should be used to clear away all traces of carbon dust which might otherwise cling to the brush holders and perhaps set up short circuits. Another good way of clearing carbon dust is to

use a tyre pump, moving the nozzle about inside th brush casing and pumping vigorously.

Precautions to Observe.

The brushes must move freely in their holders, bu no attempt should ever be made to increase the tensio of the retaining springs, unless this be done in a emergency. Some makes of dynamo have three pos



This simple method of copper-plating a carbon brush enables a broken wire connector to be soldered to the brush.

tions for the spring, each of which alters the tensio and thus allows for maintaining a reasonably consta pressure as the brushes wear down. Experience necessary, however, to know which tension should b used, and it may be said that, normally, the lighte pressure on the brush consistent with proper conta and absence of sparking should always be adopted, a excessive pressure leads to rapid brush wear.

The clamping screws which hold the brush leads ar the field winding connections must always be tigh and there should be no free strands of wire whic might cause a short circuit. Dynamo brushes are mac of a special form of carbon, and when brush replac ment is necessary the correct type for the particul machine must always be used. The hardness of th

carbon varies according to the special requirements, and great harm can be done by using brushes of the wrong grade.

The leads are secured to the brushes in various ways. If a lead should break away from the brush it can often be successfully reconnected by soldering. The method is first to copper-plate the upper half of the brush; this is done by making up a copper sulphate solution in a jam jar and suspending in it a small piece of sheet copper.

A wire is twisted round the brush so that this, also, can be suspended in the solution. The ends of the two wires are connected to a small battery, the copper to the positive terminal and the brush to the negative. In a few minutes a layer of copper will be deposited on the carbon brush, which can then be removed and washed in clean water. When dry the lead can be soldered to it and will hold securely.

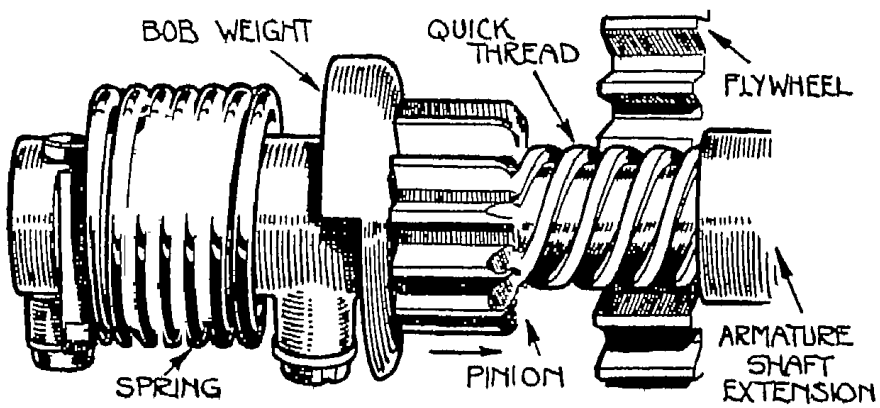
The bearings of the armature are almost invariably of the ball type and require very little lubrication. Good-quality grease should be used, and where a screw-down greaser is provided only one turn at intervals of 1,000 miles should be given, because, if the grease finds its way on to the commutator, it will give rise to trouble.

Exposed terminals must be kept clean and tight. Never connect any additional lead directly to the dynamo terminals; a wrong connection can easily cause a short circuit which may burn out the windings.

CHAPTER VII.

Starters.

A STARTER motor is very similar to a dynamo in its general construction, in that it has field windings, an armature, a commutator and brushes. There is a difference in the windings, however, as the fields are connected in series with the armature instead of being in shunt as in a dynamo. Usually there are four brushes, two being positive and two negative.



The Bendix starter drive has an out-of-balance pinion to ensure rapid engagement; the drive is transmitted through, and cushioned by, the spring.

The field coil windings are of heavy-gauge copper wire or sometimes of copper tape, whilst similarly heavy wiring is used on the armature. This is necessary because of the high amperage which passes, particularly at the instant of closing the starter switch.

A series-wound motor has the property of exerting its maximum turning effort when starting from rest, and this is just what is required when a sluggish engine has to be rotated. As the speed of the motor rises its torque

or turning effort is reduced, with corresponding reduction in current demand; thus, whereas, at the instant of closing the switch there may be a drain on the battery to the extent of perhaps 200 amps., the current will drop to, say, 30 amps. within one second and the motor will continue to rotate the engine at a speed which depends upon the bearing stiffness, oil viscosity and so on. If the starter pinion engages with the flywheel, but does not rotate the engine, the battery will remain almost directly short circuited.

When the starter switch is closed the rush of current from the battery to the motor causes an appreciable voltage drop, so that a normal 12-volt battery may show only about 9 volts at the instant of discharge.

Heavy Cables Needed.

It is of greatest importance to avoid reduction in voltage as much as possible and for this reason, as explained in Chapter II, heavy cables and connections are used between the battery and the starter. Ample wiring is necessary also to avoid overheating and, incidentally, because so large an amount of current has to be dealt with, the ammeter is not connected to the starting circuit, as a very heavy type of meter would be necessary to carry the 200 amps. or so that might pass.

Although the demand made upon the battery is so very high at the moment of closing the starter switch, the actual current consumption is not really great. Assuming, for instance, that the battery is of 50 ampere-hour capacity, and charged normally at 8 amps., the current used in making one start could theoretically be replaced in about 8 seconds.

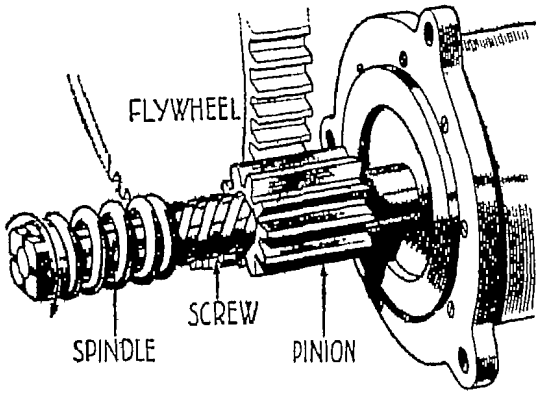
The energy consumption depends, of course, upon the stiffness of the engine, and it can be shown that 40 per cent. or so more current will be needed to start an engine from cold than when it has reached a running temperature of, say, 85 degrees C.; similarly the speed at which the engine is rotated by the starter when hot will be 50 per cent. or more higher than when cold.

It is appropriate to mention here that every effort

should always be made to use the starter sparingly. This does not mean that the engine should be cranked by hand, because starting systems are designed for use under all conditions, and if the battery, starter and engine be in proper working order there should be no need to crank by hand.

Easing the Starter Load.

If the engine does not fire within a second or two after pressing the starter button it is a mistake to keep the starter engaged; rather one should release the button and wait a few seconds, then try again. This



In the Lucas starter drive a threaded sleeve slides on the splined armature shaft and is cushioned by a spring.

gives the battery a chance to recover its voltage, whilst, at the same time, the mixture drawn into the cylinders will have had a chance to vaporize under the effect of the slight warmth set up by compressing the charges, even although they may not have fired.

Naturally, conditions can arise where the starter is definitely unable to cope with the load imposed upon it. This may happen in extremely cold weather when thick or gummy oil is used in an engine having, perhaps, rather tight bearings or closely fitting pistons.

Considerable harm may be done to the battery and to the starter if the current be allowed to flow continually whilst the engine is only just turning over. This is a case where the handle must be used, either alone

or in conjunction with the starter, in which event, of course, an assistant will be necessary to press the button or to crank the engine.

From the actual power-output point of view there is not much to choose between 6-volt and 12-volt systems, but naturally the current at 6 volts will be double that at 12 volts, therefore, other things being equal, the battery must have double the ampere-hour capacity, the cables must be heavier and the brushes very carefully designed, because these always present a certain amount of difficulty in a starter motor owing to the heavy current which they must pass without causing any considerable voltage drop. It will be clear that a reduction of one volt in a 6-volt system is greater, proportionately, than it would be in a 12-volt system.

Manufacturers have, however, dealt very satisfactorily with the brush problem and by using special grades of carbon can ensure that the voltage drop with either 6 volts or 12 volts shall be a minimum. It is most important, therefore, when fitting new brushes to use only the type recommended by the makers. To the uninitiated all brushes may look alike, but there can be very considerable differences in the materials of which they are made.

Starter Maintenance.

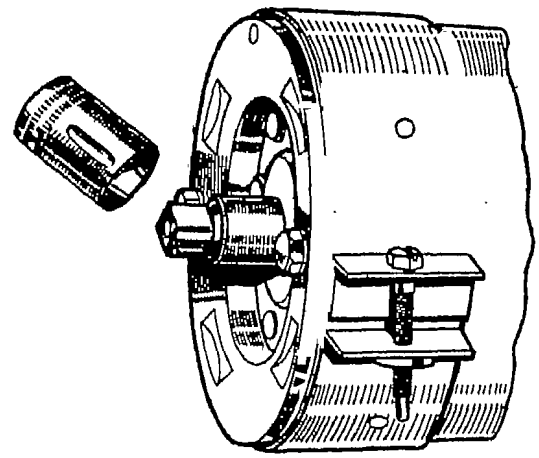
The methods of cleaning the commutators and bedding-in brushes has already been described in the chapter dealing with dynamos. Exactly similar methods can be adopted with starter motors, but it is even more important that the brushes shall be bedded very carefully to the commutator and that the brush springs be properly set.

As a rule the springs exert rather greater pressure than in the case of a dynamo, but as the starter may overheat in use there is a chance that the brush springs will lose their temper; this, of course, will result in faulty contact with the commutator and consequent lack of power in the starter. When everything is in

order the motor should behave in a perfectly reliable manner and the brushes should be good for some thousands of starts.

Bendix and Other Drives.

The normal type of starter motor rotates the engine through the medium of a pinion engaging with a toothed ring on the flywheel. The motor spindle is extended beyond the casing and carries a sleeve in which is cut a coarse pitch thread. The pinion is screwed to suit the thread and the sleeve is connected to the motor spindle through the medium of a stiff



Lucas starters have a square-ended armature shaft, covered by a cap. Should the drive jam in engagement it may be freed by turning the shaft with a spanner.

helical spring, the whole assembly being known as a Bendix drive. As a rule the pinion has a small bob-weight formed upon it so that it is slightly out of balance; the reason for this will be made clear in a moment.

The motor is mounted close to the flywheel so that the pinion, when at rest, is in line with the toothed ring on the flywheel. When the starter button is pressed the armature instantly rotates at a very high speed, but the small pinion being slightly out of balance does not at once rotate with it; instead, it lags behind momen-

tarily and is moved axially along the quick thread towards the flywheel ring, with which it then engages, the spring drive relieving the shock of the engagement. So soon as the pinion is fully home it rotates the flywheel until the engine starts or the starter circuit is opened. In either case the pinion is automatically disengaged.

The pinion must move with perfect freedom on its thread, as any sticking may result in its not being moved into engagement with the flywheel ring. That this is happening is always indicated clearly by the high-pitched hum of the motor and the absence of the familiar noise made when the pinion engages. As a rule it is necessary only to clean the thread with petrol or paraffin to free the pinion, but on most makes of car this involves removing the motor from the engine.

After cleaning, the thread should not be oiled, as it is intended to work dry; sometimes, however, a suspicion of graphited penetrating oil or some other equally thin lubricant may be beneficial.

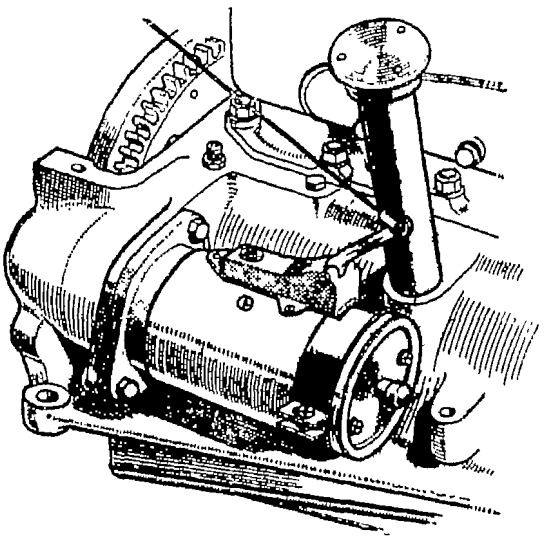
Very occasionally trouble is caused by breakage of the Bendix-drive spring, when, of course, a new one must be fitted. The springs are made in various types, so that when ordering a spare it is advisable to send the old spring as a pattern.

Freeing a Stuck Pinion.

It is by no means unknown for the pinion to jam in engagement, should the engine fail to start. When this happens the usual method of freeing the pinion is to engage a gear and rock the car backwards and forwards. The irregular movement thus imparted to the flywheel should cause the pinion to move back out of mesh.

Modern starters often have the armature shaft extended at the brush-gear end so that it projects an inch or so. The projecting portion is of square section and thus may be engaged by a spanner and turned a little when the pinion jams. This is a very effective method of freeing it. The squared end is sometimes protected by a spring-on metal cover.

On the majority of Lucas starters the Bendix drive is not used; instead, the screwed sleeve is slidably mounted on splines cut in the armature shaft. This extends beyond the end of the sleeve and on the extension is mounted a strong helical spring; a nut on the end of the shaft compresses the spring slightly against the sleeve.



Example of a built-in starter switch operated by a wire and lever from the facia board.

The pinion, which has no bob-weight, moves freely on the quick thread and in its fully home driving position comes against an abutment on the armature shaft. Thus a " solid " drive is provided.

Cushioning the Drive.

It will be clear, however, that as the teeth come into mesh the resistance to rotation imposed upon the pinion will set up a reaction which causes the sleeve to move axially so that it compresses the spring.

In this way a cushioning effect is provided; furthermore, if the teeth of the pinion and flywheel ring are not exactly in a meshing position the " give " of the spring prevents damage being done to the edges of the

teeth. As the spring does not carry the full driving load, however, breakage is most unlikely.

In the latest drives of this kind a clip is provided to hold the pinion in its free position. This avoids all risk of its moving along the thread and coming into occasional contact with the rotating flywheel. The pinion disengages instantly from the clip when the starter circuit is closed.

There are certain types of starter in which the pinion may be engaged by axial movement of the armature so that the teeth come into mesh without shock. So soon as they are fully engaged rotation takes place in the ordinary way.

In one system of this kind the pinion is moved into mesh by means of linked levers coupled to a pedal on the floorboard. Inter-connected with the levers is an arrangement whereby the brushes are lifted from the commutator, thereby dispensing with a switch. The action of depressing the pedal first moves the pinion into engagement and then lowers the brushes on to the commutator so that the motor starts. When the engine fires a free wheel in the motor gearing comes into action and continues to operate until the pedal is released, thus withdrawing the pinion and lifting the brushes.

Dynamotors.

Another method of engine starting is by means of a dynamotor, which, as its name implies, is both a dynamo and a motor. The machine is coupled directly to the engine through the medium of a chain or by gearing. It is specially wound and may have two commutators and two sets of brushes, but as a rule the normal single-commutator third-brush system, as in a dynamo, is adopted. The two main brushes are of heavy section to carry the starter current easily.

One of the troubles which has to be overcome with a dynamotor is that of choosing the correct gear ratio. To obtain sufficient torque for starting, when the machine is used as a motor, the gear ratio should, of

course, be very low, but this would mean that when working as a dynamo the ratio might be too high.

Consider a ratio of 3 to 1, this would be scarcely low enough for maximum starting torque, but it would mean that with the engine running at 4,000 r.p.m. the dynamotor would rotate at 12,000 r.p.m. Suitable compromises have been adopted by manufacturers so that the machine does not have to be geared too low as a starter or too high as a dynamo.

A refinement of the system consists in providing a variable gear ratio, by means of suitable sliding pinions. With the pinions in mesh the motor can be geared down as low as seven to one or even more, but when it works as a dynamo a direct coupling comes into action so that the machine runs only at crankshaft speed. On some cars the dynamotor is directly coupled also as a motor. This is a perfectly satisfactory but, naturally, somewhat expensive arrangement.

Starter Switch Gear.

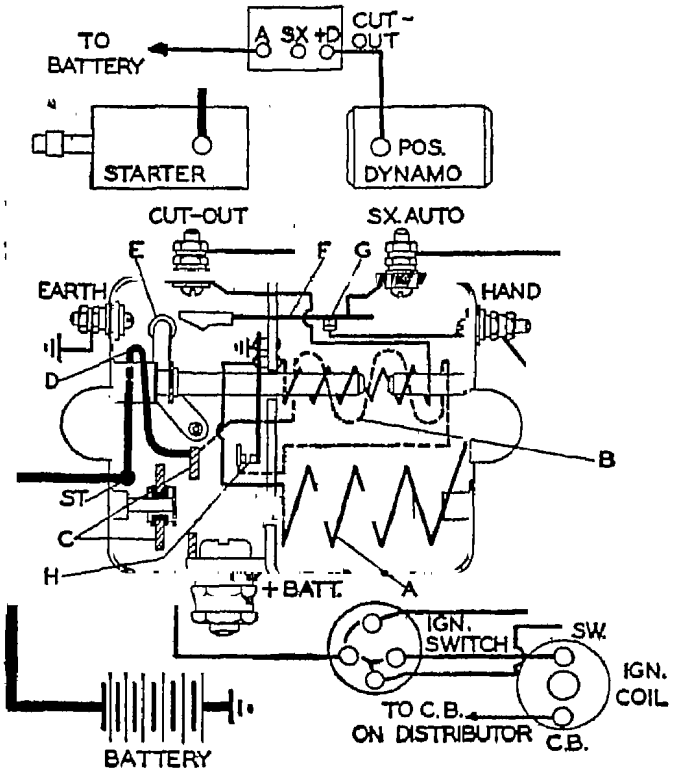
Until recently the general method of operating the starter, whether it be of normal or dynamotor type, was by means of a push-button mounted either on the facia board or on the floorboards. The heavy current passing makes it necessary for the switch contacts to be of very robust construction; also a cable from the battery has to be led to the switch, which, of course, is coupled by a further cable to the starter. The length of the cables tends to give rise not only to a voltage drop in the circuit, but also to the risk of fire should the insulation become chafed and make contact with some adjacent metal part.

Electrical equipment manufacturers therefore turned their attention to other types of switch. In one arrangement the switch is mounted on the starter body and is solenoid-operated, the magnetic circuit of the solenoid being completed through a small push-button on the facia board. This enables the cables to be shortened considerably, as the push-button requires only two small wires carrying a current of perhaps two or three amps.

Another scheme is to mount the switch on the starter body and to operate it mechanically by pulling on the wire attached to the facia board.

The Startix Automatic Switch.

Further steps to improve starter control have recently been introduced and one very ingenious Lucas arrangement provides for automatic restarting whenever the engine stalls.



Wiring diagram of the Lucas Startix automatic starting system.

The equipment consists of a sealed box which houses two solenoids; one of them operates the main starter switch, whilst the other acts as a trip switch for cutting out the starter. There is a single winding on the main solenoid and two windings on that of the trip switch, the connections being so arranged that when the ignition switch key is turned to the " auto " position current

from the battery passes through the main solenoid winc ing and causes the plunger to be pulled in.

This operates the starter switch and, at the same tim allows current to pass to the outer of the two windin of the trip switch solenoid. When the engine star and the pinion is disengaged the reduction in curre demand causes the trip solenoid to be pulled in.

Its movement acts on a lever which, in turn, opens pair of tungsten contacts. This breaks the circuit i the main switch solenoid, so that the plunger mov outwards and cuts off the current to the starter.

When this happens the outer trip switch winding i isolated, but the inner one is now energized by curre from the dynamo so that the plunger remains in it outward position. At full charging speed, with th main cut-out contacts closed, the "auto" contacts ope and insert a resistance in the winding circuit so that onl a very small current flows.

If the engine stops, the dynamo, naturally, cease generating, thus causing the trip plunger to be released The main starter switch is not, however, closed imm diately, because the movement of the trip plunger flick a spring-mounted contact arm, the vibration of whic prevents full contact being made for exactly one second

This allows the engine to come to rest before th starter pinion is re-engaged. A similar delay-actio contact in the outer winding circuit of the trip coil pre vents its immediate energizing. By this means time i allowed for the starter pinion to engage the flywhee ring before the trip mechanism opens the switch.

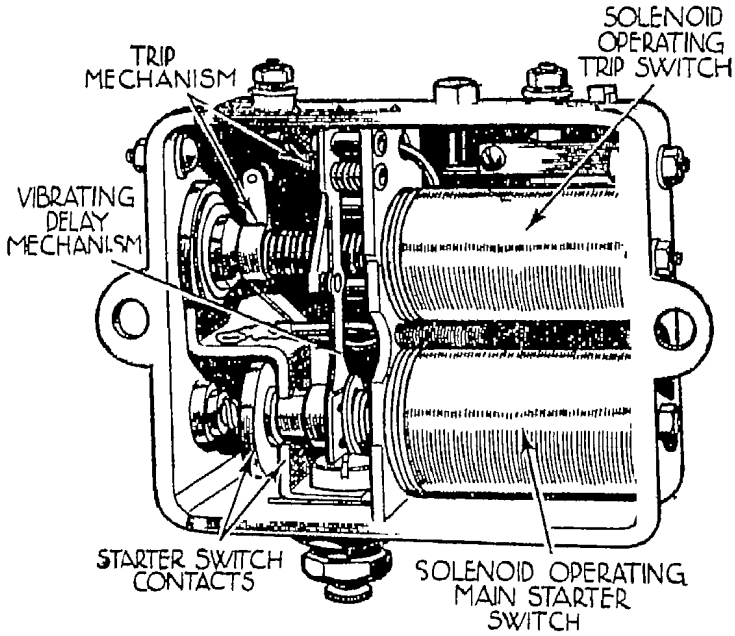
Method of Operation.

The facia-board switch used in conjunction with th Startix equipment has three positions for the detach able key; they are "off," "auto" and "hand." Th switch also carries a small push-button. When the ke is turned to the "auto" position it switches on th ignition and closes the circuit for automatic starting.

In the "hand" position the key merely switches o the ignition and the starter is put into operation b

pressing the small button, which is a relay switch so connected to the automatic mechanism that it causes the main solenoid winding to be energized and to close the starter switch.

The " hand " position of the switch is used, of course, when automatic restarting is not desired or when, owing to a run-down battery, the engine must be cranked by hand. It would be used also if the dynamo



General arrangement of the Startix automatic control mechanism.

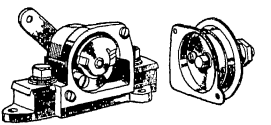
failed to charge, because then, in the "auto" position, the trip switch solenoid would not be energized; consequently the starter would cut in at one-second intervals. No damage is done to the flywheel ring if this happens, and if it is not convenient to stop for examination of the dynamo, one can turn the switch to " hand " and carry on.

The Startix switch box is sealed and no attempt should be made by an amateur to gain access to the interior. If repair or adjustment be necessary the work should be done at a service station.

The Pedomatic Switch.

In the Pedomatic starter—also a Lucas device—the motor switch is incorporated with the accelerator pedal. The mechanism consists of a casing which contains the switch contacts and a clutch controlled by a vacuum-operated diaphragm, the necessary suction being obtained by a connection to the inlet manifold.

When the engine is stationary a spring stop keeps the clutch engaged, so that a slight pressure on the accelerator pedal will close the switch. So soon as the engine starts, the induction vacuum, operating on the diaphragm, causes the clutch to disengage, thus opening the switch and allowing the accelerator to be used in the ordinary way.



The Lucas Pedomatic starter switch which is operated by movement of the accelerator pedal.

The clutch is so designed that the pedal must be in the idle position before the starter can be switched on. This ensures that there shall be no risk of the motor being cut in when, with a wide throttle opening, the induction vacuum may be so low that normally the diaphragm would allow the switch to close.

If the engine stalls, the accelerator pedal must be released fully before the starter switch can be engaged; furthermore, so soon as the engine fires, the pedal must be momentarily released, otherwise the starter will not be switched off.

The Pedomatic control requires no adjustment, but the external moving parts—link gear and so on—should be lubricated occasionally. If necessary the control may be disconnected to leave the pedal free for normal use, the starter switch being operated by hand.

CHAPTER VIII.

Batteries.

THE need for having a battery on a car will be obvious when it is remembered that a dynamo generates current only when the engine is running and there are times when a supply of electricity is needed without running the engine. Current is, in fact, required actually to start the engine.

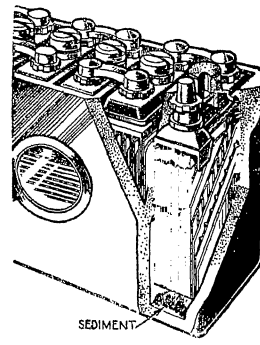
A storage battery, or accumulator as it is sometimes called, does not store or accumulate electricity in the form of current but, instead, it converts the current supplied to it by the dynamo into the form of chemical energy which it is capable of reconverting into current to supply an external circuit.

A battery consists of a number of self-contained cells arranged, for convenience, in a compact case. In each cell there are two sets of plates, positive and negative. They are immersed in a solution of sulphuric acid and water; this is known as the electrolyte. Each plate consists of a lead grid into which special forms of paste, consisting of oxides of lead, are pressed. Lead peroxide is used for the positive plates, and what is known as spongy lead for the negatives.

Each set of plates is joined by a special form of welding to a common connecting piece. The plates are arranged alternately, side by side, which means that there must be an odd number in one set, and it is usual to have one negative plate in excess of the positives; for instance, in a seven-plate cell there would be four negatives and three positives.

Insulating the Plates.

It is essential that plates of opposite polarity shoul not touch each other; they are, therefore, held apa by pieces of non-conducting material known a separators. These must be porous in order to allow th electrolyte to come into full contact with the plates an



Arrangement of the plates and ribbed separators in a battery. Sediment tends to form at the bottom of the cells; if it touches the plates a short circuit may be caused.

they must also have a certain amount of mechanica strength. Sometimes wood is used for separators, whils a special form of threaded rubber has proved extremel satisfactory. This material is quite unaffected by th acid and does not soften or crack in use. The C.A.V threaded rubber separator consists of a corrugated shee with thickened spacing ribs; an immense number c short cotton strands, arranged transversally, allow th electrolyte to flow readily between the plates and thi ensures that the internal resistance of the cell shall b kept at a minimum.

Special care has to be taken with batteries for car use to allow for the very high discharge rates sometimes required. The plates must be very thin, as it is surface area which counts, therefore a number of thin plates in a cell will be more effective than a few thick ones. No matter how many plates be used, however, a single cell cannot be made to give more than two volts. Actually, a cell which has just been charged will show, on test, something over 2.5 volts, but this will fall rapidly and settle at two volts until, of course, the cell becomes discharged, due to use.

The Capacity of a Battery.

The amperage or capacity of a battery is governed by the surface area of the plates and is denoted in terms of ampere hours, usually at the 10-hour or 20-hour rate. This means that the battery may be discharged at so many amps. for 10 hours or for 20, as the case may be.

Let us consider, for example, a 50 ampere-hour battery. This would be able to give 5 amps. for 10 hours or 2.5 amps. for 20 hours. The special construction of a car battery, however, enables it to supply an exceedingly heavy current for a short period, as when working the starter motor. We have already seen in this connection that a current of 200 amps. or more may be withdrawn for a few seconds.

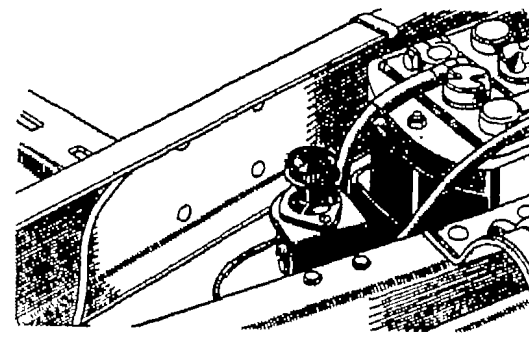
The charging rate of a battery is, roughly, one-tenth of its capacity, so that a 50-amp. battery should be charged at 5 amps. This, however, is not a hard-and-fast rule and it will be found on most cars that a charging rate in excess of the theoretical standard is provided excepting, of course, in the case of voltage regulator systems. It is also usual nowadays to provide a two or three-rate charge, as already explained in the chapter dealing with dynamos. This allows the current to be cut down when the battery is known to be fully charged.

Avoid High-rate Charging.

It is a mistake to charge always at a high rate. In this connection many drivers appear to believe that use of the starter motor so drains the battery of current that continuous full-rate charging for a lengthy period is necessary to make good the loss. This is a fallacy.

If a quick start be obtained the current used will be replaced by the dynamo in about half a minute, whilst, even if the starter has to be used several times before the engine fires, five minutes should be ample for replacing the used current. These times are, of course, based upon full-rate charging.

For daytime use the only drain upon the battery is that set up by the ignition coil, which will not take more than about 2 amps., and the occasional use of the electric horn. Small demands, such as those made by



Arrangement of the Lucas battery master switch which also cuts off the ignition.

the windscreen wiper, direction indicator, stop light and so on, can almost be disregarded.

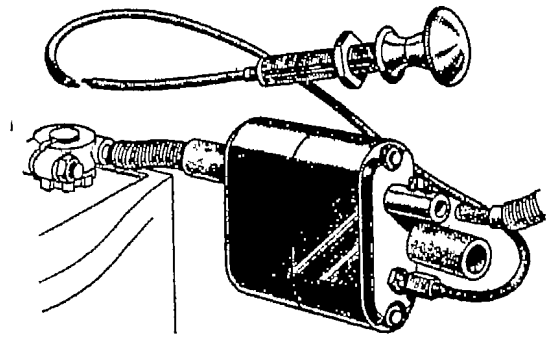
It is clear, therefore, that continuously to maintain a charging current of 8 amps. or so with a fully charged battery is altogether needless and, in fact, may be actually harmful, as we shall now see.

Chemical Action of a Battery.

We must revert for a moment to the construction of a cell and make it clear that the electrolyte, already mentioned, consists of a sulphuric acid solution and it

is this which, acting upon the lead oxides in the plates, allows the necessary chemical changes to occur. When a cell is discharging the chemical change is such that some of the lead oxide and some of the spongy lead is converted into lead sulphate. When this happens the sulphuric acid is reduced and water is formed; this causes a reduction in the density of the electrolyte.

Upon charging the cell a reverse action takes place, the sulphate being converted again into lead peroxide and spongy lead whilst the density of the electrolyte increases. Normally, in a fully charged cell the density



The Beemac battery master switch is provided with a remote control.

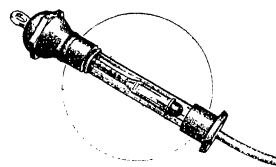
will be 1.25 to 1.3, whilst when the cell is discharged to a voltage of, say, 1.8 the density of the electrolyte may be about 1.15.

When a battery is fully charged and is still supplied with current, electrolysis of the water in the electrolyte sets in and this brings about a condition known as gassing. Gas is, in fact, being formed, as electrolysis produces oxygen from the positive plates and hydrogen from the negatives; the electrolyte itself bubbles or effervesces and as the water is thus being decomposed into its constituent gases it will be clear that not only will the level of the electrolyte in the cells be lowered but, in addition, the strength of the solution will be increased because only water is being driven off, the sulphuric acid remaining unaffected.

These two conditions are bad for the battery and should be avoided, more especially as a third condition can arise through overcharging in which the active material is expelled from the plates. This is harmful in that it may set up internal short circuits or reduce the capacity of the battery.

Measuring Electrolyte Density.

As the state of charge and general condition of a cell affects the density of the electrolyte, it will be clear that if the density can be measured an accurate guide to the condition of the cell will be available. Measurement of the density can readily be carried out by use of



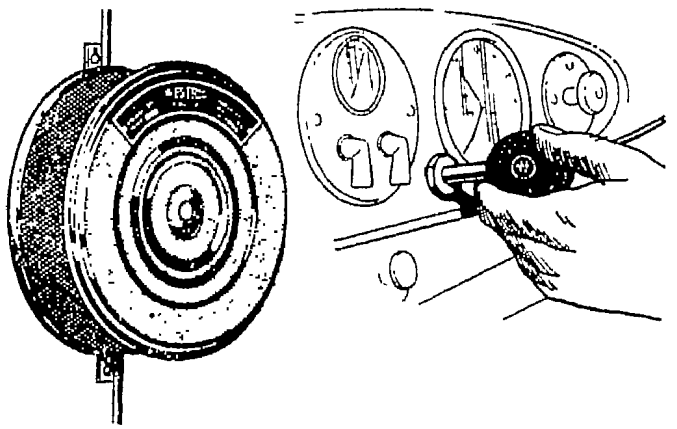
A typical form of hydrometer with which the density of the electrolyte can be tested.

an instrument known as a hydrometer. This consists of a form of glass syringe having a rubber bulb at one end and a rubber or ebonite tube at the other. Within the cylindrical centre portion is the hydrometer itself, which is a glass float weighted at its lower end and provided with a stem which is graduated in terms of density.

To use the instrument the bulb is squeezed and the nozzle dipped into the cell to be tested, through the orifice exposed by removing the screwed stopper. Upon releasing the bulb a supply of electrolyte will be drawn

up into the syringe and the hydrometer will float in this to a height determined by the density. The reading is taken by seeing which of the graduations is level with the top of the solution.

It is advisable to make more than one test so that the readings can be carefully checked. Afterwards, the bulb is squeezed so that the electrolyte is returned to the cell and a similar test is then made in the next cell until all have been checked. If the densities shown in all the cells are above normal, distilled water should be added to the electrolyte, but it is no use taking a



The Westric home battery charger, showing the facia board plug connector.

further test until the battery has been placed on charge, because there will not have been sufficient mixing of the solution.

Special Forms of Test.

If one or more of the cells shows considerable variation in specific gravity from the others it is a sign that some fault has developed and a proper examination by a service station is desirable. There are special forms of testing apparatus, not available to amateurs, which

will indicate at once the condition of a battery. The usual method is to adopt what is known as the cadmium test, which at once shows up faulty cells. Sometimes the necessary correction can be made by adjustment of the specific gravity of the electrolyte, but it may be necessary to remove the plates from the cell for examination and renewal as required.

It sometimes happens that a battery, whilst being in normally good condition, becomes so discharged that the dynamo on the car cannot make good the deficiency. When this occurs separate charging from the mains must be undertaken. This job can, of course, be done readily at a service station, but now that an electricity supply is available in almost every household charging can be done at home. Current supplied from the grid system is alternating and, therefore, not usable for battery charging until it has been rectified; that is, converted to constant direction.

Home Battery Charging.

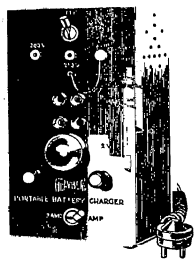
There are several proprietary battery charging devices on the market designed with a particular view to home use. They are plugged into the house supply and connected to the battery, which they will then charge in a few hours. The majority of the makers of home-charging outfits appear to favour valve rectification, but examples having a metal rectifier are also available. Upon the question of running costs it may be said that an average charger, having a d.c. output of about 16 volts 6 amps., would consume 150 watts, which, with current at, say, 1d. per unit, means that an 8-hour charge would cost a little over 1d.

The best method of using a battery charger is to install it permanently in the garage and to provide leads which will reach easily to the plugging-in point on the car. This can be mounted on the facia board or in any other convenient place. The plugs supplied with charging outfits are so arranged that they cannot be wrongly connected.

Fuses in the circuit ensure absolute safety in operation and, if the apparatus be set for a trickle charge, it may be used frequently in winter. This will ensure a " lively " battery for dealing with a stiff engine.

In cases where the mains supply is direct current very simple and inexpensive charging apparatus can be installed, but it will be more costly to run. The necessary resistance can conveniently take the form of carbon-filament lamps wired in parallel to build up the required amperage.

Metal-filament or gas-filled bulbs do not pass enough current to act as charging resistances, but the carbon-filament type, readily obtainable from most electrical

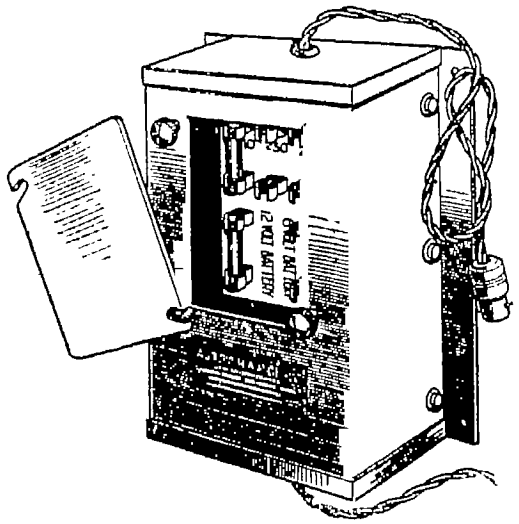


The Heayberd charger has a two-rate output and will deal with 2-volt to 12-volt batteries.

dealers, are very satisfactory in this respect. As a guide to the amount of current passed by the lamps, it may be said that one of 32 c.p. on a 230 volt circuit will take rather less than .5 amp. A carbon-filament lamp of this c.p. is rated at 140 watts, but, of course, more than one will be needed if anything more than a mild trickle charge is to be supplied to the battery.

Charging and Heating.

The proper course, therefore, is to make up a charging board on which are mounted, say, six battern-type lamp-holders together with fuses, a switch and the necessary terminals. The lamp-holders are wired in parallel so that the amount of current that passes can be regulated by increasing or decreasing the number of lamps in use. Electric engine—or radiator—warmers are in fairly regular use in winter, and, with direct



Fuse connectors in the Autocharger enable 6-volt or 12-volt batteries to be charged.

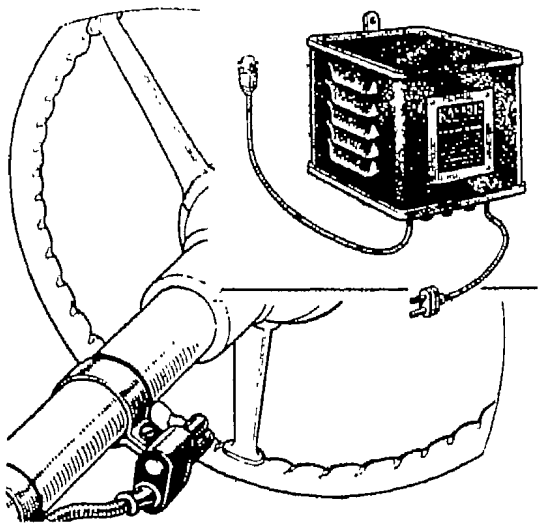
current, it is a simple matter to adapt the engine-heater as a resistance for the battery charging circuit so that, when the car is garaged for the night, the battery can be given a trickle charge. The heater will, of course, be placed under the bonnet in the ordinary way; thus two very advisable winter services are performed at approximately the cost of one.

Electrolyte Level Must be Maintained.

It has already been mentioned that during charging the water in the electrolyte may be driven off, thus increasing density of the solution. The need for fairly

frequent examination of the level of the electrolyte in the cells, therefore, becomes apparent and it is not carrying caution to excess to make the examination fortnightly. This is especially so in hot weather or where the battery is mounted close to the engine or to the silencer, because natural evaporation due to heat is also to be considered.

Wherever possible, distilled water should be used for making up the level, but in certain districts the normal domestic supply water may be used safely. The governing factor is the amount of impurities, electrically speaking, in the water, and it is advisable to avoid water which contains metallic salts of any kind.



A plug and socket connection for mounting on the steering column is provided with the Karadio charger.

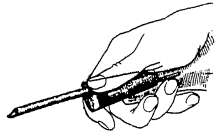
The normal correct level of the electrolyte may be taken as ¼ in. above the tops of the plates; the cells should never be filled so that the solution stands in the necks of the filling orifices, as this does not allow sufficient room for gassing or expansion.

In some types of battery, notably the later Lucas products, each cell is provided with an indicating device

which shows the level of the electrolyte and thereby makes topping up a very simple process.

Preventing Terminal Corrosion.

It is very important to keep the top of a battery perfectly dry, as the presence of moisture, especially if it be slightly acid, will set up terminal corrosion and



A simple pouring device for topping-up cells with distilled water. It fits into the neck of a bottle.

may even cause a short circuit between the cells. The stoppers of the filling orifice should always be screwed down tightly on their rubber gaskets and the terminals should be coated with petroleum jelly or with anti-corrosive grease.

The actual terminal lugs and busbars will not corrode, as they are made of lead, but the connectors and their clamp bolts are sometimes attacked by the acid. An effective and safe way of removing the corrosion is to soak the parts in a strong alkaline solution made by dissolving washing soda in warm water.

Repairing Cracked Cells.

Sometimes the top of a battery will crack and allow the escape of electrolyte or, rather, of the vapour. As a general rule it is advisable to return the battery to the makers for professional attention, but quite often a satisfactory repair can be made by first drying the top of the cell thoroughly and then melting together the edges of the crack by the application of a hot iron.

lternatively the crack can be filed or scraped out to V section, after which Chatterton's compound is elted into it.

The foregoing remarks apply only to the tops of the lls, as there is no satisfactory home method of repair- ig the moulded cases, although, as a get-you-home

This Hobson facia board gauge indicates the height of the electrolyte in the battery.

neasure no doubt a liberal coating of Chatterton's ompound would prove satisfactory.

Before leaving the subject of batteries it may be said hat their proper care and maintenance should be egarded of the first importance because upon them lepends so much the efficient working of modern cars.

CHAPTER IX.

Lighting Equipment.

ALL cars are required by law to exhibit "during th hours of darkness" two white lights facing forwarc and indicating the width of the vehicle, and one re light facing rearwards. In addition, the rear numbe plate must be illuminated, and it is usual for this to b done by the bulb which serves the red light.

The light given, as a rule, by the obligatory sic lamps of a car is not sufficient for safe driving on dar roads, therefore most cars are fitted, as standard, wit two headlamps. Sometimes these are combined wit the side lamps, but, more generally, they are quit separate.

Other lights used on a car are those which illumina the instrument panel; saloons usually have one or mo roof lamps, and there are stop lights, reversing light spot lights and even mascot lights.

The source of current supply is, of course, the ca battery, charged by the dynamo. Generally, the roa light switches are mounted on the facia board or in th centre of the steering wheel, whilst the switches whic control the auxiliary lights are placed in various co venient positions.

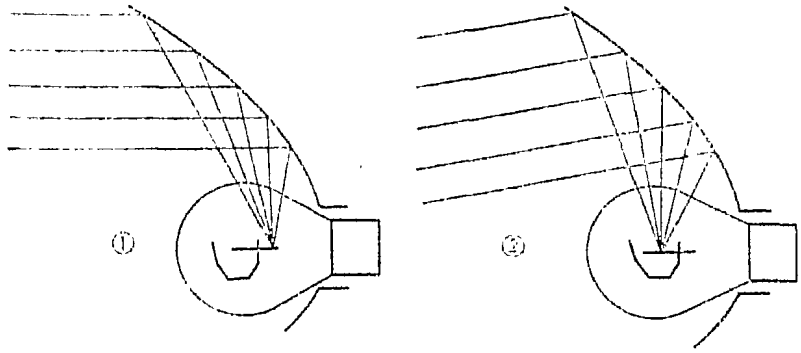
One switch at least, however, is never hand operated it is that which controls the rear stop light. It come into action when the brake pedal is depressed, and generally located on the chassis close to the ped anchorage. On cars where the brake pedal and leve are interconnected, the stop-light switch is usually wire in series with the ignition switch. This arrangemer allows the stop light to be cut off when the engine

stopped; otherwise the lamp would remain alight whenever the car was parked with the hand brake on.

Reversing lamps are sometimes controlled by a switch operated by the gear lever when it is moved to engage "reverse." This is a very convenient arrangement when a car has to be manœuvred in the dark. A separate hand-controlled switch can be used to cut out the automatic one in the daytime.

Points Concerning Bulbs.

The bulbs used in modern lighting systems are almost invariably of the gas-filled type. The term "gas filled" means that instead of there being a vacuum within the glass bulb—as was the case in earlier times—it is filled with an inert gas, such as nitrogen or argon. By this



A double-filament lamp bulb showing (1) how the main filament light is reflected and (2) how the secondary out-of-focus filament gives a dipped beam.

scheme it is possible to raise the tungsten filament to a greater degree of incandescence; thus for a given current consumption a much more powerful light is produced.

In domestic lighting the term "half-watt" is often used to describe gas-filled bulbs; it is intended to imply that the bulbs give 2 candle-power per watt of current used. This is actually a rating which does not apply to lamps of under 300 watts.

Car-type lamp bulbs may use about 1 watt per candle-power, but only by a photometer test can the actual candle-power be measured. It should be remembered,

also, that, owing to the shape and positioning of t filament, the light emitted will be more powerful in c direction than in another. For this reason, wh absolute accuracy is required, it is usual to give t mean spherical candle-power (M.S.C.P.), as plotted a polar graph.

Whilst, when new, the efficiency of a bulb deper upon its design, the care expended upon its manuf ture and so on, there may be considerable losses wh it is in use. Granting a fully charged battery, gc wiring and clean connections, a bulb should give a v close approximation to its rated candle-power at rated wattage.

Conditions can arise, however, which will cause a l drop in efficiency. Chief amongst these is the age of the bulb. After a considerable period of use inner surface of the glass becomes blackened, due emissions from the filament.

The darkening of the glass naturally cuts down amount of light that can pass; thus although the f ment is taking its proper current and producing rated candle-power, a large part of this is absorbed passing through the black glass. It is false economy continue using blackened bulbs; throw them away a fit new ones. The increased driving comfort will well worth the cost.

Avoid Cheap Bulbs.

One other point in connection with bulb efficien It is seldom worth while to buy very cheap bulbs. So of them are good and will stand the most exact candle-power and consumption tests; their effective also is reasonable. Others, however, may be heavy their current demands or badly made in that the g is not properly cemented to the cap; the two may p company when the force necessary to engage the p with the bayonet joint is applied.

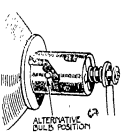
When dealing with unbranded bulbs, especially headlamp type, one should beware of super-brilliai

It may seem very attractive to have additional candle-power for no increase in current consumption, but as this result is achieved, as a rule, only by shortening the life of the bulb it is not so good.

The scheme adopted is to over-run the filament—that is, to make it somewhat smaller than normal. This causes it to glow more brightly, but it will not last long; the extra voltage passing will burn it out.

Single and Double Contact.

Car-lamp bulbs are usually of the small bayonet-cap (S.B.C.) type and single or double contact, according to whether the wiring system be single or double pole. In



This method of focusing a single-contact bulb by means of a three-notch bayonet bulb holder is used sometimes on headlamps and on sidelamps.

single-pole systems the current returns to the battery by way of the car frame. The lamp bulbs, therefore, have a single central contact in the base of the cap—but insulated from it—to which one of the filament leads is soldered. The circuit is completed by securing the other filament lead to the metal of the cap. Assuming that the current enters by the central contact, it will pass through the filament and leave via the cap body, which is, of course, making contact with the metalwork of the lamp, and as this member is earthed an easy path for the current is provided.

In double-pole systems two insulated wires lead to each lamp and the bulbs have two contacts in their base, no current passing through the car frame.

Single-pole wiring is very conveniently simple, b it is important that all the earthed connections shall perfectly clean. The formation of a film of rust, instance, on a lamp mounting can easily set up so hi a resistance to the current flow that the bulb will do more than glow dimly, or even refuse to light at all.

When such a fault exists the lamp must be unbolt and the contact faces scraped bright. Do not, howev paint them afterwards, as paint is an effective insulat Further rusting can be prevented by applying pai enamel or cellulose around the edges of the joint af it has been fully tightened.

Bulb-holder Faults.

The bulb holder in a lamp is provided with bayo slots for engagement by the two pins which project fr the bulb cap. Inside the holder are one or two spri loaded plungers—one in the case of single-pole wir and two with the double-pole system.

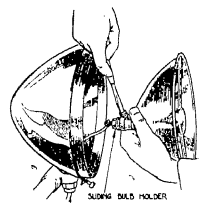
For explanatory purposes we will assume single-p wiring and, therefore, a single plunger in the la holder. The wire leading from the switchboard is c nected to the back of the plunger, which, of cou presses against the centre contact in the bulb cap.

Two points may be mentioned here; if the spring the plunger should become weak, or if the plunger its should stick, faulty contact will be made with the bu and the lamp either will not light at all or will flick This trouble is very rare, but it has been known to occ There is a possibility also of the plunger tip becom corroded, so that an insulating film is formed betw it and the bulb contact; this can well result in a light failure.

When fitting a new bulb difficulty is sometimes perienced in pushing it in far enough to engage bayonet joint. The trouble is due, as a rule, to excessive amount of solder having been applied on centre contact, and the cure is to file away some of solder.

Care must be taken to clean away all particles of solder from the surrounding insulation, otherwise a short-circuit may occur. This point is particularly important with double-contact bulbs, because there is, as a rule, only a small gap between the two contacts.

One other point in connection with bulb fitting: In some types of lamp there is a sleeve outside the bulb holder, and if the two pins which project from the cap are too long they will foul the sleeve and prevent the bulb from being inserted. Here, again, matters can be



The normal type of Lucas headlamp is focused by sliding the bulb holder in or out after the clamp screw has been slacked.

put right by the judicious use of a small file, with which the length of the pins can be reduced slightly. Do not, of course, clamp the bulb in a vice, as this would be sure to damage it; all the necessary filing can be done with the bulb held gently with the fingers of the left hand.

When dealing with the wires leading to the bulb holders it is important to see that there are no loose strands, which might set up a short-circuit by touching an adjacent earthed part. As a rule, in the case of double-contact bulb holders, there is a small piece of insulating material between the two terminals. If this be missing a piece of cardboard or a short length of insulating tape, folded over, can be inserted.

Care of Reflectors.

Lamp reflectors usually are of parabolic shape and formed from thin sheet metal. The reflecting surface is silver-plated and highly polished. To preserve the lustre it is usual for manufacturers to cover the surface with a special form of varnish.

For this reason no attempt should ever be made to clean reflectors with metal polish, but it is permissible occasionally to wipe them with a piece of very soft material, such as a silk handkerchief. If the silvered surface has no varnish coating and shows distinct signs of tarnishing it may be cleaned with jewellers' rouge, but nothing more abrasive than this should ever be used.

A dull reflector will absorb a considerable amount of light, therefore if maximum efficiency is desired one should have no hesitation in sending the reflector away for replating; this is a comparatively inexpensive job. The reflectors are, of course, protected by the glass fronts of the lamps, and if a glass be cracked or broken no time should be lost in obtaining a new one, because otherwise the reflector will very quickly tarnish.

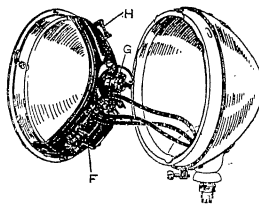
Focusing Arrangements.

Headlamps are almost invariably provided with some form of focusing device, so that the projected light may be used to the best advantage and according to individual requirements. In some cases the bulb holder is provided with three bayonet slots, in steps, as it were, so that three positions of the bulb relative to the reflector are obtainable. In other designs the lamp holder is slidably mounted in the reflector and clamped by means of a screw at the back.

There is another arrangement in which the adjustment is made by turning a screw situated in the rear of the lamp body. This scheme is rather to be preferred, as focusing then becomes a very simple operation, which can be carried out without first removing the front of the lamp.

The stepped bayonet holder has certain advantages, and where standardized bulbs are used one of the three positions available may be relied upon to provide the desired focusing. To make an alteration it is necessary only to remove the lamp front, but it must be borne in mind that if the job be done whilst the lamp is alight the bulb will be extremely hot, and should therefore be held with a cloth.

Where the focusing is carried out by means of a sliding bulb holder it is necessary to remove the reflector



A Lucas solenoid-operated dipping headlamp. A fuse (F) protects the windings whilst a spare fuse (H) is carried. By slacking the clamp screw (G) the bulb can be moved for focusing.

from the lamp body before access can be gained to the clamping screw. As a rule the reflector is held in place by three spring-loaded tongues which fit into slots formed at its front edge. If one of these be first disengaged by pressing it down the reflector can then be released easily from the other two. There will be a sufficient length of wire within the lamp body to enable the reflector to be drawn far enough forward to get at the screw.

It is a good plan when about to focus a lamp of this kind to slack the clamping screw just enough to allow the holder to be pushed in or pulled out fairly easily, but it should not be loose. The reflector can then be

replaced and the holder moved as necessary by grasping the bulb.

It is now necessary to say something regarding the actual focusing operation. An approximate setting can be arrived at by driving the car to a point about 25 ft. from a flat vertical screen, such as a garage door, a wall or a fence. Switch on the headlamps and note the position of the discs of light thrown on to the screen. These should be quite clearly defined and circular.

How to Focus Headlamps.

If the two discs are not at the same height they must be made so by altering slightly the angle of the lamps. This is done by slackening the clamp nuts of their mountings and moving them as necessary. The centres of the two discs of light should be the same distance apart as the actual centres of the lamps. This measurement can easily be made with a long rule or with a piece of string stretched taut. The height of the discs of light should be slightly less than the actual height of the lamps from the ground.

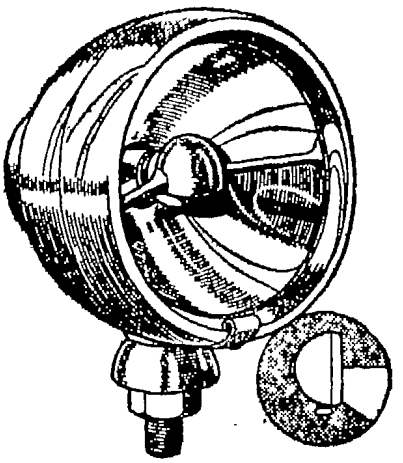
When this setting has been made the two lamps can be focused by movement of the bulb holders until both discs projected on the wall are of the same diameter. This may be all that is required to provide a good driving light, but, in general, it will be found much more satisfactory to regard the preparations just described merely as a preliminary to more accurate setting, which must be carried out on the road.

The Final Setting.

Drive the car—at night, of course—to a suitable stretch of straight road where there are no lamp-posts or other sources of light. If the road has a kerb or a row of trees along it so much the better. Drive in a perfectly normal manner and note the projection of the light-beams ahead. If they are not quite satisfactory stop the car, mask one lamp by throwing a coat over its front and adjust to angle or focus of the exposed lamp as required. Treat the other lamp in the same manner and try again.

Some little patience and a considerable amount of adjusting may be necessary before ideal conditions are arrived at, but take care, after each alteration, to get back into the driving seat in order to judge the result, as a quite erroneous opinion is liable to be formed if the beams are viewed when standing more or less level with the front of the car. Finally remove the reflectors to lock their clamping screws, secure the lamp fronts and tighten the mounting nuts.

Actually the last-named job should be done first, because if the lamp fronts be difficult to replace there is



A hooded bulb and split reflector are used in the Lucas Paslight to provide a flat-topped beam which prevents dazzle.

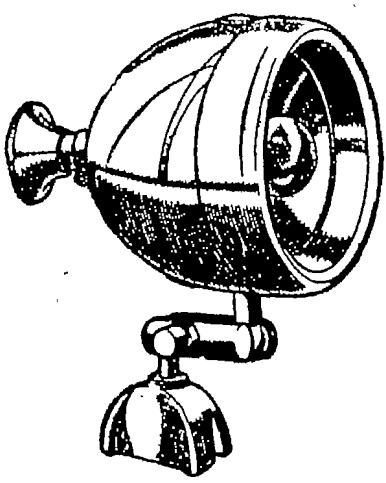
the possibility that in pushing them on the lamp body will be shifted, unless it has first been tightened.

Where the near-side lamp is provided with a dipping reflector it is advisable before assuming the adjustments to be correct to test this lamp in the dipped position, because it may happen that, although the straight-ahead projection is satisfactory, the dipped beam does not come quite where it is desired. In that case one must, as it were, split the difference, bearing in mind that it is very advisable to have efficient illumination when the beam is dipped.

Headlamp Glasses.

In most cases special forms of glass are used in headlamps with the object of producing a diffused light around the main beam. Sometimes the glass is merely stippled, but on the more expensive lamps it may be domed or convex and moulded into a series of vertical convex lenses; in addition, there may be a special centre formation composed of a series of prisms, from which the wide-angle beam is refracted.

It will be clear from this that in the event of a lamp glass being broken an ordinary piece of glass will not



In the Salora foglamp a special bulb and a gold-coloured reflector are used. External focusing means are provided.

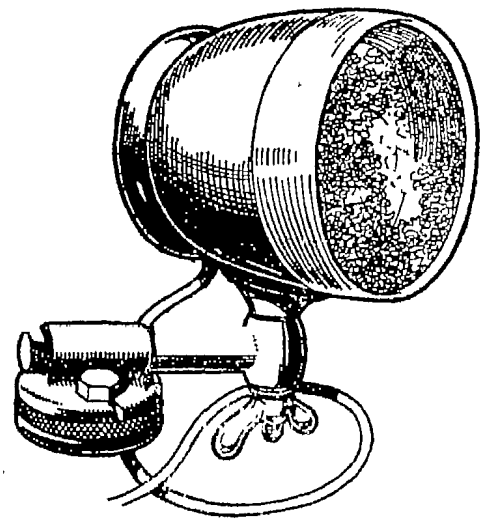
be a satisfactory substitute, although there is every reason for fitting it temporarily in order to protect the reflector whilst the proper lens is being obtained. Any glazier will cut the necessary disc of plain glass for a few pence.

Dipping and Switching Systems.

Let us turn now to a consideration of the dipping and switching mechanism usually incorporated in headlamps. In the latest examples the control is almost invariably electrically operated, but there are many cars still on the road in which the near-side reflector is dipped by pneumatic means, and there are systems which

actually tilt both lamps on their mountings by mechanical control—that is, by rods and levers or with a Bowden wire.

With electrically operated dipping control the mechanism is carried within the body of the near-side lamp. It takes the form of a solenoid, the plunger of which pushes a bracket on the under side of the bulb holder, thus tilting the reflector to the dipped position. Upon reaching the end of its travel the plunger opens a pair of contacts, thereby bringing into circuit a high-resistance winding, which limits the amount of current



A foglamp fitted with Nebulite glass which has special light-filtering powers by which back-glare is avoided.

flowing to a fraction of an ampere. When the current is switched off the reflector is returned to its normal position by means of a spring.

The dipping mechanism gives very little trouble in practice, but should it show sluggishness in operation or should the off-side headlamp fail to cut in or out when the control switch is moved an examination of the dipping mechanism will be necessary.

It can be exposed by removing the lamp front and taking out the reflector in the manner described earlier in this chapter. The solenoid and its contacts will be

found mounted on the reflector frame, and it will be noticed that there is a small cartridge fuse placed across the windings, and that there is a spare fuse mounted in clips nearby. Make sure that the working fuse is held firmly in its clips. The various contacts can be examined for signs of burning or corrosion and cleaned as necessary. In general, however, any fault developing in the dipping mechanism should be entrusted to a service station for correction.

Pneumatic Switching.

On the pneumatically operated dipping systems a small air cylinder is mounted on the reflector frame; it is provided with a piston the connecting rod of which is attached to the reflector. Incorporated with the dipping device is a switch by means of which the off-side lamp is extinguished when the reflector is dipped.

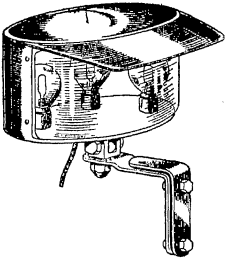
The air cylinder is connected by rubber or metal tubing to another cylinder mounted on the steering column or some similar point, readily accessible to the driver. The cylinder contains a plunger which when pulled upwards creates a vacuum in the pipe line and the reflector air cylinder. This causes the piston to move up the cylinder, thus dipping the reflector.

The troubles which can arise with this system centre mainly in air leakage past the plungers or through faulty tubing. Each plunger is provided with a leather cup washer, and should these become dry they will allow air to escape. From time to time, therefore, a few drops of thin oil should be fed into the plunger cylinders. The operating plunger has a small screw in its side, and if this be taken out the oil can be introduced through the hole exposed, after which the screw is replaced.

The cylinder on the reflector has a small air-escape hole in its side, and oil can be applied through this; at the same time not more than one drop should be allowed to fall on the plunger spindle, but take care not to overdo the oiling, as surplus lubricant may find its way on to the switch contacts and cause faulty

operation. Perished rubber tubing should, of course, be replaced by new lengths where necessary.

On some cars a dipped effect is achieved by the use of double-filament bulbs, one filament being set out of focus. Movement of the dipping switch cuts out the main filament and cuts in the auxiliary, which, by reason of its position relative to the focal point of the reflector, causes the dipped beam to be projected. This scheme is not in very general use as, for manufacturing



A floodlight effect is obtained with the Gamage foglamp in which three bulbs are used. The hood prevents upward glare.

reasons, it is not practicable to use high-power filaments. The idea has, however, the great merit of simplicity.

Driving in Fog.

Before leaving the subject of lamps some consideration must be given to the question of fog driving. It can be shown by scientific means that a white light is a drawback in fog, as it sets up back-glare, which is very confusing to the driver. Certain forms of yellow light, however, do not possess this drawback, but it must be understood that it is not so much a question of the

colour of the light as its optical properties that ha
be considered.

Light is of varying wavelength, starting with t
short waves at one end of the spectrum and ending
much longer waves, comparatively speaking, at
other. Fog is composed of an infinite number of
particles of water. They are so small, in fact, that
form a definite barrier to the passage of all ligh
short wavelength, which is thus reflected back by
particles.

Long-wave light, however, can pass them; ther
if one can filter out the short-wave light without al
ing the long waves, a very useful illuminant for dri
in fog is obtained. This has been done commerc
by means of a special form of glass known as Nebu
which stops all light of wavelength greater than g
in the spectrum, but allows the yellow part to pass
undiminished power; thus, by using Nebulite gl
in the headlamps or in a special fog lamp a consider
help in fog driving is obtained.

There is also a special cadmium-yellow bulb a
able, which produces similar results, but failing t
special arrangements, satisfactory progress can usu
be made in fog by covering the lamp glass with
yellow paper. The headlamps should be dipped,
it may be worth while to tilt them considerably on
mountings, so that the beams are projected downw
close to the front of the car. A much better sch
however, is to have some approved form of fog
carried low down on the near-side dumbiron
directed towards the kerb.

CHAPTER X.

Wiring.

THE wiring system of a car is essentially of a somewhat complex nature, and must tend to become more so as increased use is made of electricity for various purposes. In earlier times the wiring proved very troublesome owing to the fact that the actual types of cable used were not really suited to the job.

Unlike household and similar electrical wiring, the cables on a car are called upon to withstand the effects of oil, heat, dampness, vibration and, quite possibly, of corroding gases. Cable manufacturers have been able easily to produce wires which are quite unaffected in ordinary circumstances by these disturbing factors; thus, provided the wires are reasonably well secured and not run close to a hot exhaust pipe or stretched tightly across points which have considerable relative movement they are most unlikely to give trouble during the life of a car.

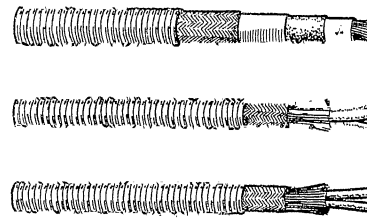
All of the main wiring—that is, from the battery to the switchboard, fusebox, lamps and so on—is carried out at the factory with wires which must conform with a definite specification regarding current-carrying capacity, insulation, external protection and mechanical strength. Quite often several wires, individually insulated, will be braided together within a common insulation, and this, in turn, may be protected by a metallic braiding.

The Reason for Coloured Insulation.

For convenience in making the connections at each end of a cable it is usual to adopt various specified colours for the insulation; thus if a wire having, say,

purple insulation be connected at one end to any gi terminal, its fellow terminal at the other end can found merely by looking at the insulation of the w until purple be found. Quite often car wiring grams indicate the insulation colours of the wires, t enabling any particular circuit to be traced very reac

It is not advisable for an amateur mechanic to in fere with the main wiring of a car, at least with a v to dismantling any part of it, but, of course, indivic



Types of cable used on car wiring systems. Insulation and current-carrying capacity are important factors.

sections may safely be examined, terminals may tightened and so on. It should be borne in mind, h ever, that on many switchboards and junction boxes terminals are very close together, so that a slip wit screwdriver blade might cause a violent short-cir and possible burning-out of an important compone

If, therefore, it is proposed to disconnect any clo arranged wires, one or both of the main leads from battery should be detached; this assumes, of cou that no battery master switch is fitted. When dea with electric wiring one must guard particularly aga loose strands of wire, which might cause a short-circ and also, in the case of armoured cables, one must that the metallic armouring cannot make contact v

a live terminal, because with an earth return system this would give rise to a direct short-circuit.

Using Armoured Cables.

The armouring usually takes the form of a thin strip of soft metal, such as aluminium, wound helically over the outer layer of insulation. The armouring should stop at least half an inch from the bared end of the wiring. It can be secured by looping it back about two turns and pulling the end taut, when the surplus may be cut off flush. To be definitely on the safe side a turn or two of insulating tape can be applied at the end.

When baring the end of a wire—that is, stripping back the insulation—care must be taken not to cut through any of the strands, as this will reduce the current-carrying capacity of the cable. A sharp pen-

Stranded wires, where joined, must be well twisted together and soldered. Good-quality insulating tape is applied over the joint.

knife used carefully is quite effective for removing the insulation, but if this be partly of cotton, scissors may be necessary to snip off the frayed ends. When the wire strands are exposed they should be scraped gently with a knife to remove all traces of insulation from their surfaces.

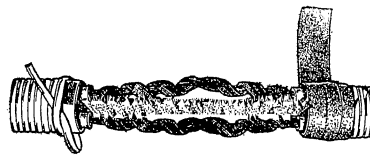
Joining Wires.

If two wires are to be joined together, it is not sufficient merely to twist the ends together; they must be soldered. Twisting is well enough as a temporary measure, but the wires may oxidize at the joint and set up a high resistance.

The flux used for soldering must be of a definite non-acid variety, otherwise the joint may corrode; "Fluxite" soldering paste can be recommended for electrical joints.

After soldering all traces of flux should be cleaned away, and the joint must be protected by the application of insulating tape.

The black sticky variety is very useful in this connection, but there is a great deal to be said in favour of the pure rubber tape often used by electricians. This is extremely tough and very elastic, so that it can be wrapped tightly round the joint, and even if several layers be used there will be no inconvenient increase in the diameter of the wire. Rubber tape is, to a certain extent, self-vulcanizing, so that it will not tend to



When joining twin wires care must be taken to see that they cannot touch each other. They must also be insulated from the armoured casing.

unwrap; but to be on the safe side, a touch of rubber solution can be applied to the end, or if this be warmed by holding a match near it and then pressed tightly on to the layer beneath it will make secure contact.

If a wire has to be clamped to a terminal it is not very satisfactory to twist the end of the wire round haphazard, as some of the strands may break loose and set up a short-circuit. Use a suitable ring or fork-end terminal soldered to the wire. There is an immense variety of terminals now available from wireless dealers.

Cable Sizes.

When fitting a new electrical accessory to a car take care to use suitable wiring for connecting it into the circuit. The size of a wire is designated by the number of and gauge of the strands forming the core. Thus a

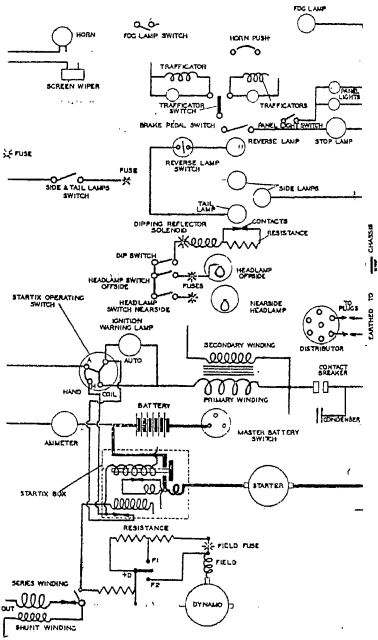
cable may be known as 35/30, which means that there will be 35 strands of wire each of 30 S.W.G. A cable of this size would be capable of carrying the full dynamo current. Where lesser currents have to be dealt with, such as, say, for a lamp, 14/30 cable would suffice.

It is always best, with wiring, to err on the generous side, but one would hardly use 35/30 armoured cable to supply a dash-light, as something very much smaller, even household lighting flex, would do well for this service. It is as well to bear in mind that electric horns of the high-frequency type must always be fed through cables of ample section, because if there be a voltage drop in the wiring the note of the horn will suffer.

It is not too much, therefore, to use 35/30 cable for a horn of this kind, and if the wiring system be of the earth-return variety great care must be taken to see that an efficient earth is provided; that is, the horn bracket must be scraped bright and it must be bolted to an unpainted surface forming part of the metalwork of the car. If a definite earthing point on the actual horn mounting cannot be arranged, a second wire can be led from the horn to any convenient point on the framework.

Fog lights and road lights require similar care in their wiring, although, as a rule, smaller cable of, say, 14/30 type can be used. When making the connection to the source of current supply some little care may be needed in choosing the right point.

On some makes of car a special terminal is provided in the fusebox, to which all electrical auxiliaries can be connected. The terminal is protected by a fuse, and the arrangement is remarkably straightforward and convenient. Where such facilities for making the connection are not available there will almost certainly be a junction box with a spare terminal; failing this, the connection can be made on the positive terminal of the ammeter. Those who do not care to interfere with the



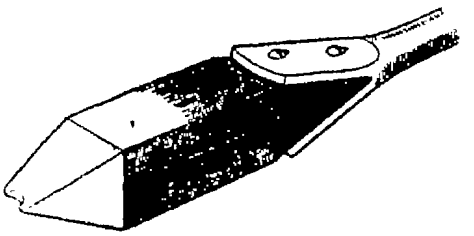
A typical Lucas wiring diagram applying to a six-cylinder car. Note the connections for the battery master switch.

existing electrical connections may lead the wires of their new fitting direct to the battery, interposing a switch and a fuse at any convenient point.

Proper care must be taken to see that the cables are safely secured, so that they cannot swing about or chafe. Small metal clips may be used in this connection, or the new cable may be bound with insulating tape to any adjacent fixed point.

Protection by Means of Fuses.

The fuses which protect the wiring system of a car are extremely important features, and no attempt should ever be made to alter them in any way. On some cars



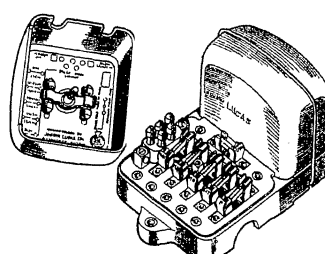
By filing a groove in the nose of a soldering iron a better flow is obtained when dealing with twisted wire joints.

there is only one fuse, which is in the dynamo field circuit and has already been dealt with in the chapter relating to dynamos. The tendency on modern cars is to fit a fuse in all the main circuits, and, as a rule, the fuses are of the cartridge type held in spring clips.

The cartridge consists of a small glass tube with brass caps on each end. The fuse wire passes through the tube and is soldered to the caps. Within the tube, also, is a strip of paper upon which is marked the current-carrying capacity of the fuse. Obviously, the makers know the maximum load which may be applied safely to the wiring of any given circuit, and they arrange the fuse to blow when that particular load is reached.

Generally there is an ample margin available, so th in the case of, say, the auxiliary circuit several adc tional electrical devices may be connected without fe of overloading the fuse. This will blow, howeve should there be a short-circuit which gives rise to heavy flow of current.

The fact that a fuse has blown is a definite indicatic of a fault in the circuit, therefore there is not much poi in fitting a new fuse until the fault has been locate and corrected. Sometimes a little logical diagnosis wi enable the trouble to be traced very quickly.



On several makes of car fuses are provided in all the main circuits, in addition to the dynamo field fuse. Note the spare fuses.

As an instance, if the fuse were to fail at the momen of switching on the screen wiper, it would be correct t assume that this unit or its wiring was at fault. If however, the wiper was working steadily at the tim it could hardly be the cause of the trouble. By a similar process of elimination various other circuits car be ruled out and the faulty one soon discovered. In a bad case, however, take the car to a service station.

Fuse Replacement.

Never, in any circumstances, be tempted to fit a heavy fuse in an effort to prevent continued blowing. It is, in fact, a mistake to use any fuse other than that supplied by the makers of electrical equipment. One has to bear in mind, however, that an emergency can arise where no approved replacement fuse may be available; in that case a suitable substitute must be found.

Look at the label in the fuse cartridge, which will indicate that the fuse was of so many amps.; one can then call at any electrical dealer or wireless shop and obtain a length of ordinary fuse wire of the specified amperage, or if the only obtainable wire is of lower amperage, which is quite likely, several strands of it can be used in parallel.

Let us assume, for example, that a 15-amp. fuse is needed but that only 3-amp. wire is available; obviously, then, if five strands of this be used they will have a combined capacity of 15 amps. The wire can be wound temporarily round the fuse clips, but no time should be lost in obtaining the proper replacement from an authorized service station.

Battery Master Switches.

Mention of a battery master switch has already been made in this chapter, whilst two types are illustrated in Chapter VIII. It is a device which can be very strongly recommended and is fitted as standard on many cars. The purpose of the switch is completely to isolate the battery from the rest of the electrical system.

There are various types of master switch available and an essential of their design is that they shall be capable of carrying the full-load current imposed by the starter without overheating or causing a voltage drop. Another point is that when "off" they should cut out the ignition system.

This is desirable if the switch is to function as a safety measure in the event of a short-circuit or an accident. Fire can often be prevented in these circumstances by

prompt cutting-off of the current, which otherw owing, say, to a broken wire, might cause a sp which could ignite any loose petrol on the car or in roadway.

It must be remembered that, with coil ignition, if battery be disconnected when the engine is running dynamo can feed direct to the coil, thus the eng would not stop. Furthermore, it is probable that increased voltage of the dynamo on open circuit wo burn out the coil, whilst if the lamps were alight at time these, also, might burn out.

In addition to its "safety-first" features, a batt master switch, if fitted in an inconspicuous positi makes the car thief-proof and prevents mischiev sounding of the horn or interference with other electri details.

CHAPTER XI.

Electrical Auxiliaries.

ALTHOUGH forming part of the normal electrical equipment of a car and, generally, essential to safety or to comfort, there are certain items which are rather in the nature of auxiliary fittings.

Amongst them are horns, screen wipers, traffic signals, cigar lighters, and so on. It is remarkable how electricity is being used for so many varied purposes; even electric gear changing is not unknown.

As the law requires that all cars shall be provided with "audible and sufficient" warning signals we shall deal first with these.

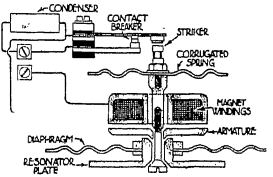
There is no exact definition of an audible warning signal as applied to cars, but electric horns are the more popular devices; these, however, may be subdivided into several classes, such as vibrator, high-frequency, motor-driven and compressed-air. Amongst other electric warning signals are bells and sirens.

It is advisable at this point to mention that no kind of warning signal may be sounded in a "built-up" area between the hours of 11.30 p.m. and 7 a.m. Because of this many motorists give silent warning by flashing a spotlight on the road ahead. For this purpose the switch may, if desired, take the form of a horn-type push button.

On modern cars high-frequency horns are the predominant type. They have the merits of being loud but comparatively musical; they are also very reliable. In principle a high-frequency horn is similar to the simple vibrating type, in which an electro-magnet

attracts an armature secured to a circular sheet-metal diaphragm held rigidly around its circumference. A contact breaker, operated by the movement of the armature, causes the diaphragm to vibrate when the control button is pressed, and the sound may be amplified by means of a suitable trumpet.

There is a limit to the loudness and to the pitch of the note that a horn of this kind can produce, but by



Details of a typical high-frequency electric horn (the Alto). A study of the diagram will show the operating principle.

an ingenious modification both of these qualities are made available. Thus, we have the high-frequency horn.

How a H.F. Horn Works.

In this the electro-magnet is of a powerful type and, generally, the armature is laminated to aid high-speed working; it is usual, also, for a condenser to be shunted across the contacts—as in an ignition contact breaker—its purpose being to prevent excessive sparking.

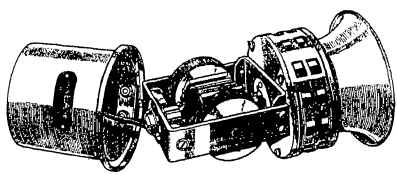
The alloy-steel diaphragm may be flat or corrugated, according to the design, and sometimes it is stiffened by the use of flat springs. By these various means a very high vibrational speed or frequency is obtained, but it is not suitable for the purpose in view. This is achieved, however, by attaching rigidly to the outer face of the diaphragm a disc, or resonator plate, of very light metal, such as a magnesium alloy.

The disc, secured only at its centre, is free to vibrate, and having so little weight its inertia is correspondingly low; thus it builds up a frequency far in excess of that of the diaphragm and causes the familiar high-pitched note.

Most high-frequency horns have an adjustment for the contact breaker, for diaphragm movement or for both. It is not advisable, however, for an amateur to do more than adjust the contact breaker as the diaphragm setting requires expert manipulation.

Contact-breaker Adjustment.

In some horns of the medallion type the adjusting screw is behind the resonator plate or in the centre of the spindle which carries it. The plate can be removed by unscrewing the centre nut and the adjusting screw is then rotated about a quarter of a turn. The horn



An example of an electric siren showing the high-speed motor and the fan cut-off ports.

button should then be pressed and the result noted. A true idea of the alteration in the sound cannot, of course, be gained until the resonator plate is replaced, but the test will show whether or not the pitch of the note has been raised or lowered, and a glance at the ammeter will show the amount of current that the horn is taking.

In this connection it should be noted that a wrong adjustment may result in excessive current consumption. It may happen, in fact, that the most desirable note, from the musical point of view, is obtained only by

the consumption of an excessive amount of current, in which case some sacrifice of the musical properties of the horn must be made.

Most electrical service stations have special arrangements for horn tuning, and as the job takes, as a rule, only a few minutes, it is nearly always worth while entrusting the work to the experts rather than to attempt it at home.

Motor-driven Horns.

The foregoing servicing suggestion applies almost exclusively to high-frequency horns, as the motor-driven ratchet type is much simpler to adjust, the only movement being that which governs the position of the striker ratchet relative to the diaphragm pip. As a rule there is a short lever at the back of the motor casing and this, if moved slightly in a clockwise direction, will push the ratchet closer to the pip.

It should not be set too close, as this will result merely in the horn making an unpleasant groaning sound, besides overloading the motor. The ideal at which to aim is a setting that allows the motor to speed up rapidly to its maximum with the pitch of the note rising correspondingly.

An electric siren consists of a high-speed motor, rather more powerful than the kind used in a horn, which drives the siren fan. There is nothing to adjust, as the cut-off vanes of the fan never vary from their initial setting. The motor commutator and brushes will require cleaning occasionally and, of course, the bearings must be oiled. It is advisable to mount a siren in a protected position, as mud or grit can be very harmful to the fan or rotor.

Compressed-air horns are operated by an electric motor which drives a small air pump. The sound is produced by the air causing tuned reeds to vibrate. A horn of this kind is, therefore, a "wind instrument" and in that respect is similar to a siren. The motor will require the usual maintenance attention from time to time and the compressor may require oiling.

Horn-button Faults.

Whatever type of electrically operated horn be used it is almost sure to be controlled by a press button, and this may sometimes give trouble. The average button consists of a metal ring, moulded into the base of the "press" portion, and a pair of contacts to which the horn wires are attached. When the button is pressed the ring touches the two contacts and so completes the circuit. A spring returns the button to the "off" position.

As a certain amount of sparking at the contacts is unavoidable, it follows that the metal surfaces become pitted and oxidized in time. When this happens the current will be unable to pass and the horn will not sound.

A temporary cure can sometimes be effected by rotating the button slightly to bring fresh surfaces of the ring into use. As soon as convenient, however, the complete button should be dismantled for cleaning. A fine file or a piece of glass-paper will remove the oxide from the surfaces. If there be excessive pitting it is a sign that rather bad sparking has been going on. In cases where one of the button wires is earthed it is important to see that effective contact is being made.

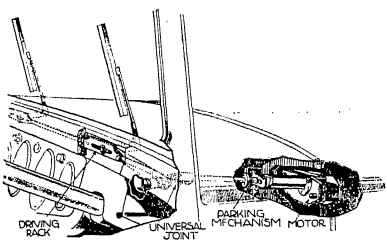
Fitting a New Horn.

When fitting a new horn to a car take care to use wires of ample section. The voltage drop caused by undersized cables may easily result in a very poor note being given by the horn. If an earth-return wiring system be used, there must, of course, be no paint or other insulating material on the bracket.

With high-frequency horns particular attention is necessary regarding the method of mounting. A really rigid support must be used, as anything flimsy will vibrate badly when the horn is working, and this will adversely affect the note. In the case of under-bonnet mounting, it may be taken that the average radiator tie-bar is not sufficiently rigid to carry a high-frequency horn.

Electric Screen Wipers.

The screen wiper is an important auxiliary on a car and, nowadays, it is nearly always electrically operated. There are several kinds in general use, but they differ only in certain points of design with regard to the motor and the wiper-arm gearing. The older Lucas type, of which there are still very many in use, has an "attraction" motor in which there is a winding only on the field magnet—the armature being a plain laminated assembly with four equally spaced poles and shaped



Dual screen-wiper blades operated by a concealed motor driving a rack mechanism mounted behind the facia board.

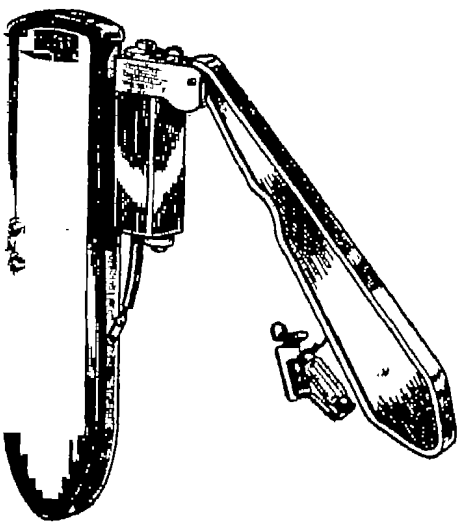
rather like a ratchet. It rotates between the field poles as in an ordinary type of motor, but instead of a commutator the armature spindle carries a small four-lobe cam, which operates a contact breaker connected in series with a field winding.

A motor of this kind is not self-starting, and when used for a screen wiper is provided with a small milled knob, which also performs the function of a switch. The action of pulling out the knob closes the circuit. The knob is then spun between the fingers and causes the armature to rotate; in doing so it operates the contact breaker so that the field winding is intermittently

energized, thus the armature is alternately pulled round and released. Its inertia carries it over the non-magnetic intervals, so that rotation is continuous.

Adjustment and Maintenance.

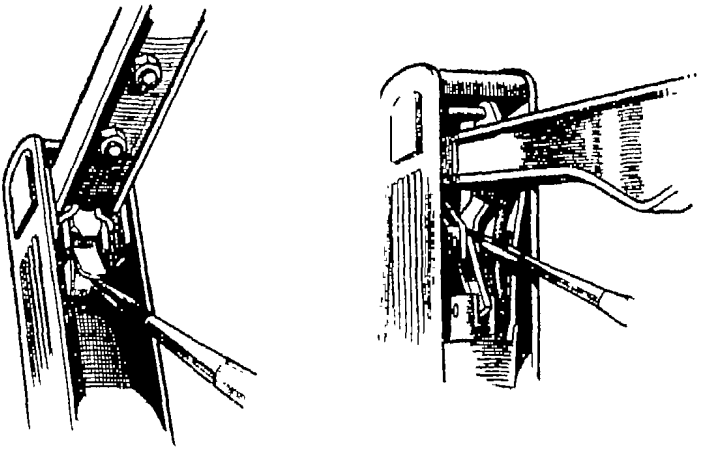
This type of motor has the merit of great simplicity and it is fully reliable. Occasionally the contact points require attention, just as do those of an ignition contact breaker. The gap is adjustable and its setting is somewhat important, as upon it depends, to a large extent, speed of the motor. One of the points is carried on an insulated plate held by two screws to the main assembly. The screw holes are slotted, so that if the screws be slacked



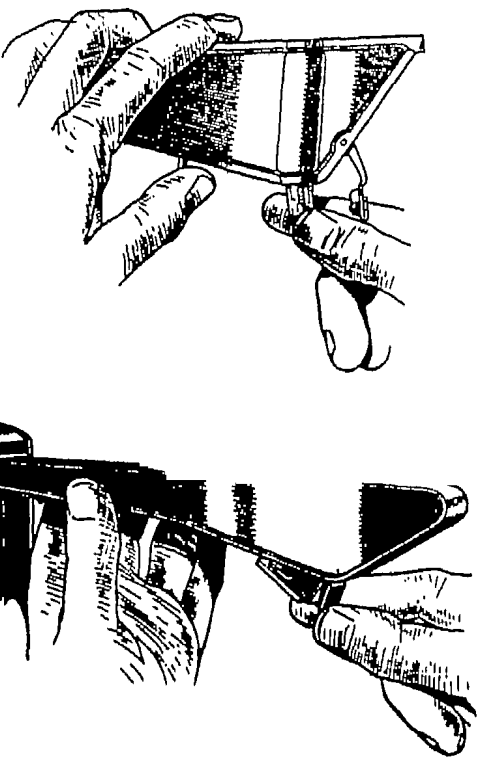
The Hunt traffic signal partly dismantled to show the solenoid and the method of removing the bulb.

back a little the plate, together with the contact, can be moved, and by this means the gap is altered.

As the armature spindle runs at a comparatively high speed it is necessary to provide reduction gearing, so that the wiper blade will not move too fast across the windscreen. It will be clear, also, that the rotary motion of the gearing must be converted to semi-rotary motion on the wiper spindle. This is done by the use



Thin machine oil, applied on a brush, will ensure smooth working of the joints and sliding contacts in traffic signals.



Methods of gaining access to the bulbs in two types of Lucas Trafficator.

of a simple form of connecting rod, which is enclosed with the gearing at the back of the motor assembly.

The gearing is accessible for lubrication or examination by removal of the back plate, and good-quality grease or petroleum jelly may be used as the lubricant; a large quantity is not required, as it will tend to set up too much drag. With this type of screen wiper the armature spindle runs in a long bearing, and this may, with advantage, be lubricated with graphited oil as, in some cases, grease will not find its way along the full length of the bearing.

Self-starting Wipers.

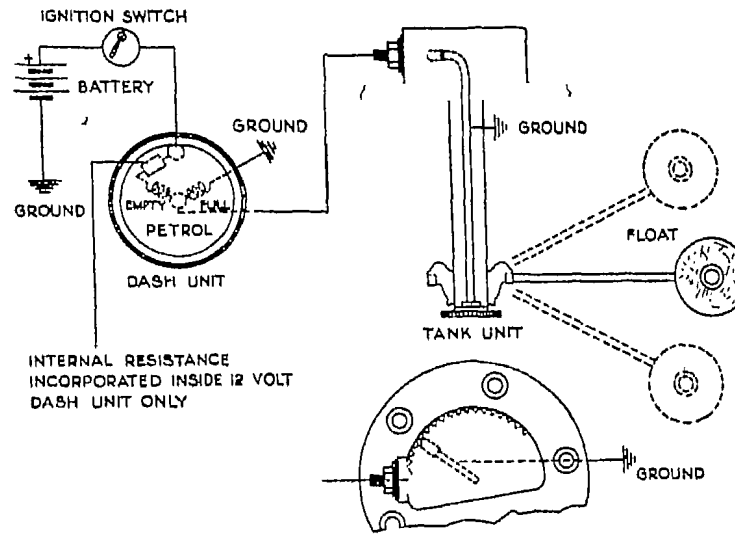
Where the screen wiper has a self-starting motor this is of the usual wound-armature type with a commutator and brushes. The operating switch may be self-contained, i.e., attached to the motor casing, or remote control may be used. The motors are designed to run for long periods without attention, but occasionally the cover should be removed for inspection and cleaning of the commutator and brush gear. The lubrication attention necessary is similar to that mentioned in connection with "spin-start" wipers.

In those types of screen wiper having tandem blades, a dash-mounted motor and concealed operating gear, the rack or chain motion will require occasional lubrication.

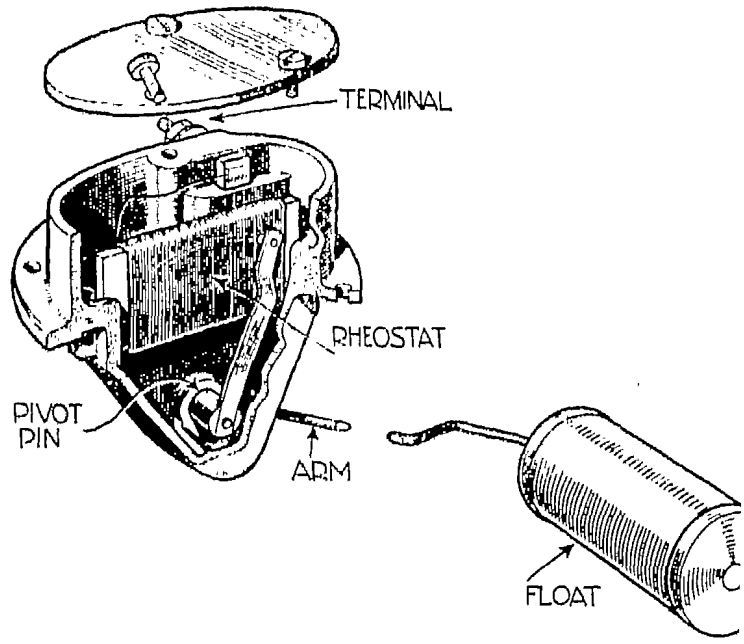
Direction-indicator Maintenance.

Direction indicators are now in almost universal use, and they require little maintenance attention. The semaphore arms are usually solenoid operated and contacts are provided to switch on the internal lamps as the arms assume a horizontal position.

The hinges of the arms require occasional and sparing lubrication with thin machine oil and the contacts should be examined from time to time. Movement of the contacts can be watched by closing the operating switch so that the arm is lifted and then switching off whilst holding the arm in the horizontal position. It



Wiring diagram of the A.C. petrol gauge. The rheostat is operated by movement of the geared float arm.



Control unit of the Smith petrol gauge. The float move the contact arm across the rheostat windings.

can then be moved up and down as necessary and, finally, allowed to drop back into its casing.

The method of changing a lamp bulb varies in different models, but always it is a quite simple operation. As a rule the festoon type of bulb is used. When lifting the arm for bulb changing or for contact examination this should preferably be done by means of the switch, instead of attempting to pull the arm from its casing by hand, as this, in some cases, may damage the mechanism. Always make sure to switch off before removing or refitting a bulb as, with the current flowing, a short circuit may be set up.

Most direction signals are wired on the earth-return system, and the earthing must be really efficient. Failure of one or both of the signals to operate can often be traced to bad earth connections. The signals should also be wired through a fuse, either the "auxiliary," which carries other electrical accessories, or through a separate one.

If the arm, after being raised, does not drop back properly into its casing examine the inside of the case for obstructions, such as disarranged cable ends. The arms drop of their own weight—they are not pulled down—and, being purposely made very light, they will not "shut up" fully if bent slightly or if the hinges are stiff.

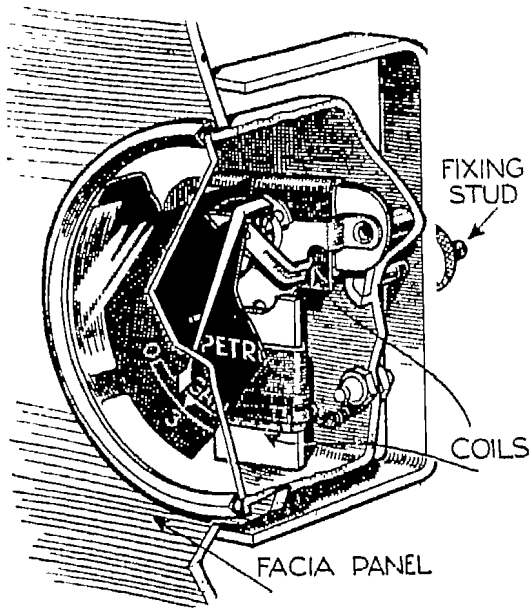
Electric Petrol Gauges.

Another important electrical accessory is the petrol gauge. It requires no maintenance attention and does not, as a rule, give trouble. In a standard type of gauge there are two units, the dial and the float assembly; they are connected by a wire, and the circuit is completed via the ignition switch, an earth return being used.

The needle of the dial gauge carries an armature swinging between two coils and moving towards one or the other, according to the magnetic "pull" exerted. This pull is controlled by the tank unit, which consists of a float attached to the end of an arm. The other end of the arm, through the medium of gearing,

actuates the contact brush of a rheostat, or variable resistance.

It will be clear, therefore, that as the level of the fuel in the tank varies, the float, in rising or falling, will cause the brush to move across the rheostat, thus altering the amount of resistance in the circuit and so varying the magnetic pull of the two dial coils. There are further technical details relating to the working principle, but they need not concern us here.



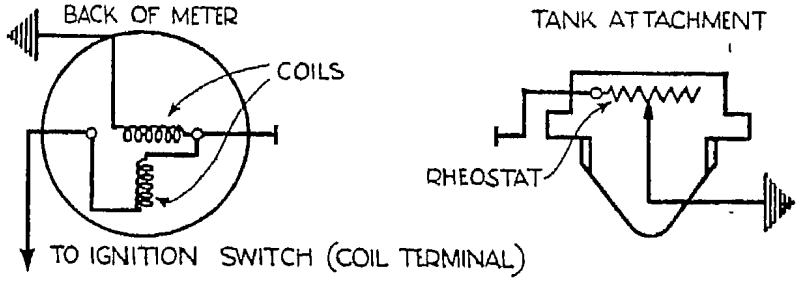
The Smith gauge unit. Movement of the hand is controlled by coils energized through the control rheostat.

Diagnosing Gauge Faults.

The presence of electrical mechanism practically inside the petrol tank gives rise to no risk of fire as the unit is sealed in a corrosion-proof casing and the float spindle passes through a gas-tight bush. Provided that the dial gauge is accurately calibrated, a true reading of the tank contents will be given, as the instrument is not affected by variations in battery voltage. Current consumption, by the way, is very low—between .16 and .10 amp.

Although neither the dash unit nor the tank unit are liable to give trouble—and, in any case, are not repairable by amateurs—external wiring faults may develop which will put the gauge out of action.

For instance, if the needle does not move when the ignition is switched on it is probable that the wire between the gauge and the switch is disconnected. If



Wiring diagram of the Smith electric petrol gauge.

the gauge shows "full" under all conditions look for a fault in the wire between the dash unit and the tank unit.

Earthing faults are indicated by the needle always pointing to "empty." If an examination fails to disclose the fault it is possibly in one of the two units, and a replacement may be necessary. This is a job for the service station.

Electric Fuel Pumps.

Electric fuel pumps are in very regular use on modern cars; the later types feed the fuel under pressure to the carburetter, but in the earlier models gravity feed was adopted. In both instances the S.U. pumps are very popular. The pressure type consists of three main parts, the body, the magnet assembly and the contact breaker.

Inlet and outlet valves, together with a filter, are contained in the base of the pump. A wound cast-iron magnet, carried within the body, is close to an armature, which is located by 11 spherical-edged brass rollers; these ensure correct positioning and absolute freedom of movement.

The contact breaker consists of two rockers, the inner of which has screwed to it a bronze rod connected to the armature. The outer rocker carries a tungsten point, which makes contact with a further point secured to a spring blade. One end of the magnet coil is connected to the blade whilst the other end is connected to a screw terminal.

The circuit is completed to earth via a short flexible wire connected between the outer rocker and one of the screws in the moulding of the contact-breaker housing. Where double-pole wiring is used the wire is led from the rocker to an additional screw terminal.

When the pump is at rest the contacts are closed. So soon as the current flows the magnet is energized and attracts the armature. This deflects the pump diaphragm, causing petrol to be drawn into the pump chamber. Towards the end of its "stroke" the armature trips the contacts, which, in opening, break the circuit, so that the armature and diaphragm return when contact is again made, and the cycle of operations is repeated.

Pump Maintenance.

Electrical troubles are unlikely to develop, and little maintenance attention is needed as the width of the contact-breaker gap is of no importance.

Should the pump refuse to work when current is switched on, disconnect the lead from the terminal and strike the end against the body of the pump. If current is available sparks will appear. The moulded cover of the pump is then removed for examination of the contact breaker. If the points are closed and a spark cannot be struck off the terminal it is probable that the points are dirty. Conversely, open contacts indicate that the armature has not gone right back.

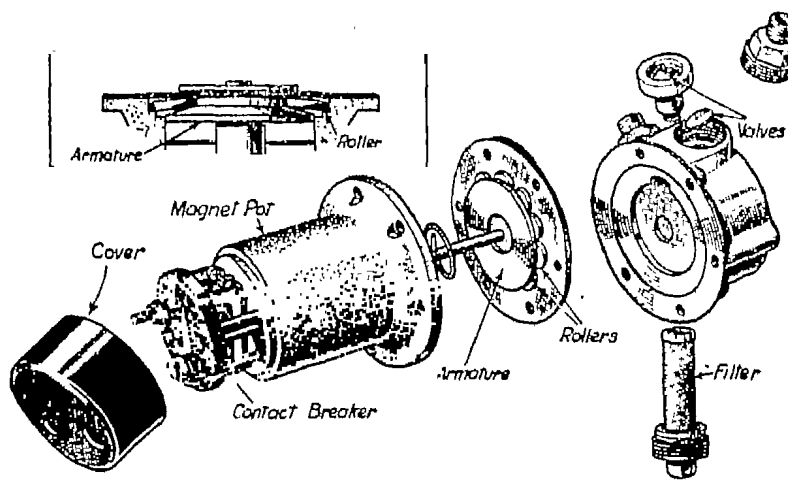
This trouble may be overcome, as a rule, by slacking the six screws which hold the magnet housing to the body and making sure that the diaphragm is not sticking to the magnet housing; alternatively, it may be dirt that is causing the sticking, in which case it will be

necessary to dismantle the main magnet assembly.

A noisy pump indicates an air leak on the suction side, whilst steady working without petrol being delivered is usually a sign that dirt has lodged under one of the valves. If the pump becomes very hot and seems to have difficulty in working, look for an obstruction in the delivery pipe.

Gravity-feed Pumps.

The gravity-type S.U. pump is of very simple construction. An electro-magnet, energized by the car battery in the ordinary way, attracts and releases,

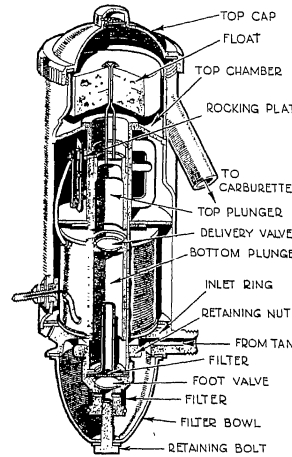


An S.U. pressure-type pump dismantled to show the general construction. (Inset) How the armature is supported on spherical rollers.

through the medium of a contact breaker, a plunger connected to the pumping element. As the plunger approaches the top of its stroke it moves an iron sleeve upwards, and this short-circuits the magnetic flux existing at the upper poles of the magnet system.

The weakening of the upper magnetic field has the effect of strengthening that at the lower poles, which then attract an iron armature operating the contacts. When these open the magnetic circuit is broken, the pump plunger falls and the cycle is repeated.

The pump is not liable to electrical derangement, bu occasionally the contact breaker should be exposed fo examination of the points. Grit in the pumpin element may cause sluggish working or complete failure

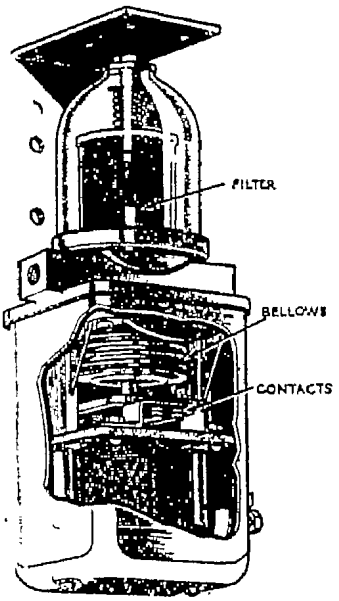


This sectional view of an S.U. Petrolift pump shows clearly the arrangement of the various parts. The float controls the movement of the pump.

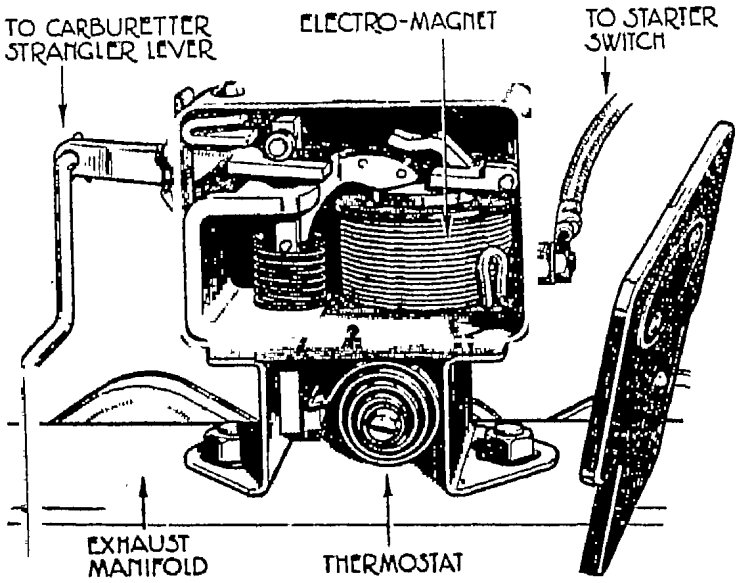
whilst it is important to see that there are no air leak on the suction side of the unit.

A Bellows Pump.

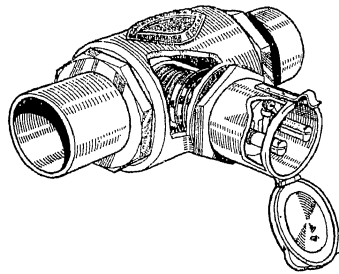
In the Autopulse fuel pump a coil having a hollo core attracts an armature which carries two pairs c tungsten contacts; a helical spring, located in the hollo



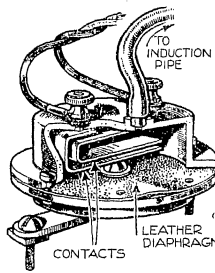
In the Autopulse fuel pump a metallic bellows forms the pumping element. It is operated by an electro-magnet.



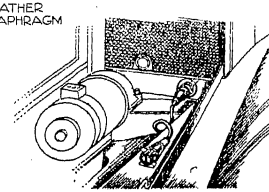
A strangler control operated by an electro-magnet through the medium of a thermostat.



The Bray engine heater fits into the lower waterpipe and is run from the mains.



(Left) A vacuum-controlled switch which cuts off the ignition so soon as the engine stops.



(Right) The Melvin immersion-type radiator heater with plug for connection to the electric mains.

core, returns the contacts to the "open" position. Projecting upwards from the armature is a small screw which engages with the pumping unit.

This consists of a metallic bellows, expanded and contracted by movement of the armature and working, of course, in conjunction with the usual inlet and outlet valves. A domed-glass filter unit surmounts the complete assembly.

The Autopulse pump works normally on the earth-return wiring principle and is unlikely to give trouble in use. The dual contacts very seldom require attention but the pump is not difficult to dismantle when necessary.

Engine Heaters.

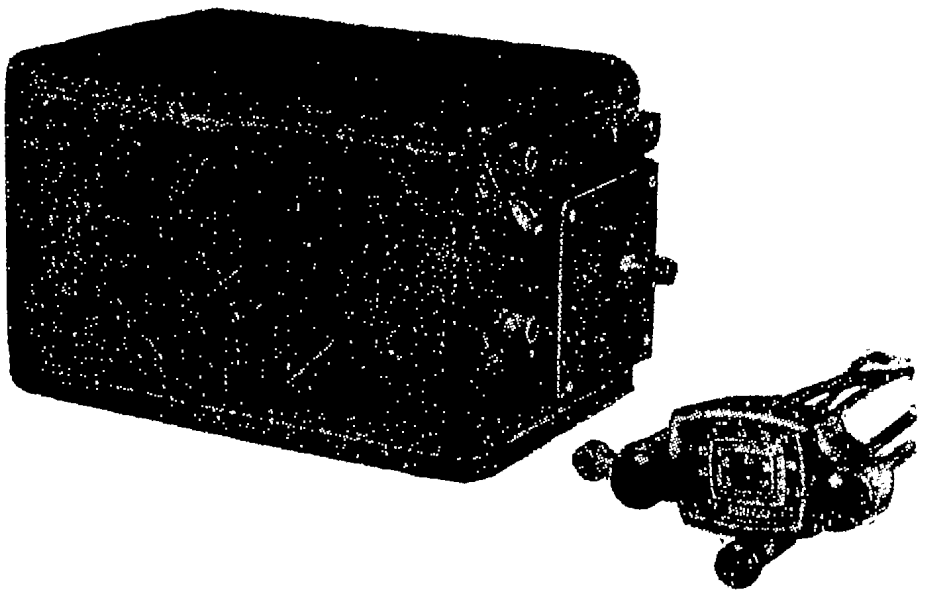
In the chapter dealing with batteries mention was made of mains-operated engine heaters. These may be of the lamp or resistance type for external use, or they may be of the immersion type.

The last-named are very convenient, as they are permanently fitted either in the base of the radiator or in the lower water pipe. A plug and socket connection for the mains supply is provided. By maintaining the water at a reasonable temperature a rapid start from "cold" is ensured. Heaters of this kind consume only about 150 watts. The elements are fully enclosed, and there is no obstruction to the normal flow of water.

CHAPTER XII.

Radio Equipment.

THE fitting of radio receivers as an integral part of the equipment of a car is becoming increasingly popular. It is estimated that there are about 10,000 radio sets fitted to cars and motor coaches in this

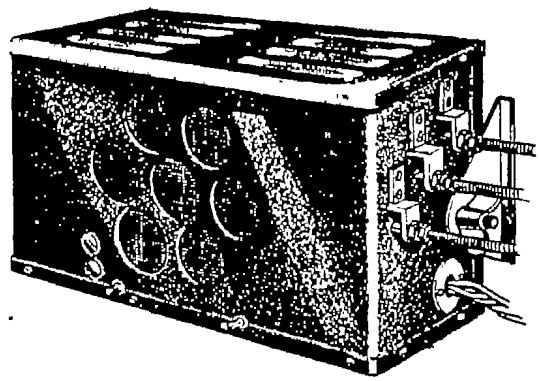


The self-contained Philco unit—Model 803 T for 12 volts and 803 for 6 volts—with remote tuning control, which is transversely lighted.

country. In America the number is about 2,000,000, and certain American cars are sent to this country with a radio installation as standard equipment.

Owing to the possible sources of electrical disturbances on a car special precautions must be taken to prevent interference. Similarly the question of vibration has to be considered. From the point of view of signal range and quality of reception, the design and position of the aerial are important factors.

It is usual with car radio to take the current from the car battery, the low-tension supply being tapped off direct. The high-tension current, however, is a little more difficult, as it is necessary to step up the voltage. This may be done by a vibrator-convertor or a small motor generator may be fitted. A more simple method is to obtain the high-tension current from a separate dry battery, which will need replacement from time to time. In the most popular car radio installations both high- and low-tension supplies are taken from the car



An entirely self-contained set marketed by the General Electric Co., Ltd.

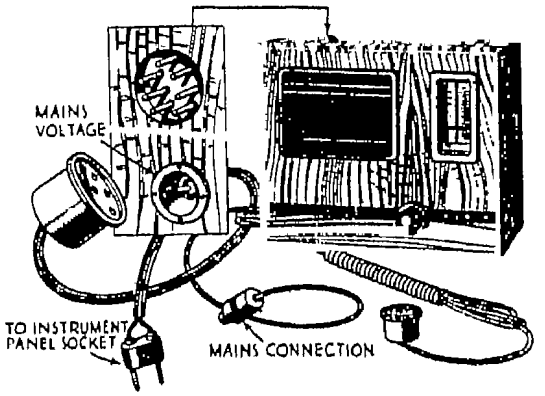
battery, the drain on which varies from 2.5 amp. to 5 amp. (from 12 volts).

The Aerial.

If the roof of the car be of fabric or wood, a sheet of wire gauze may be used to form an efficient aerial; it would, of course, be concealed. When the car has a metal roof then the aerial must be fitted underneath the car. Hitherto, such a type of aerial has taken the form of either a number of insulated copper rods or sheets of wire gauze held between rubber or fibre clamps slung under the running-boards. It may be mentioned that many specially built bodies afford no support for an aerial of this type.

An ingenious aerial constructed on a new principle

has been introduced recently by the makers of Philips radio equipment. The aerial itself is suspended by means of rubber tubing, the tubing being clamped to the chassis frame. If the aerial, which consists of copper rod in the form of a " V," strikes an object, this flexible mounting prevents risk of damage. Such an aerial has a certain wave length which eliminates part of the interference from the electrical installation. The closer the aerial of this type is fitted to the ground



The Decca set can be operated either from the car circuit or from the household mains.

the greater its efficiency. There should be no reason why an amateur might not install it quite easily.

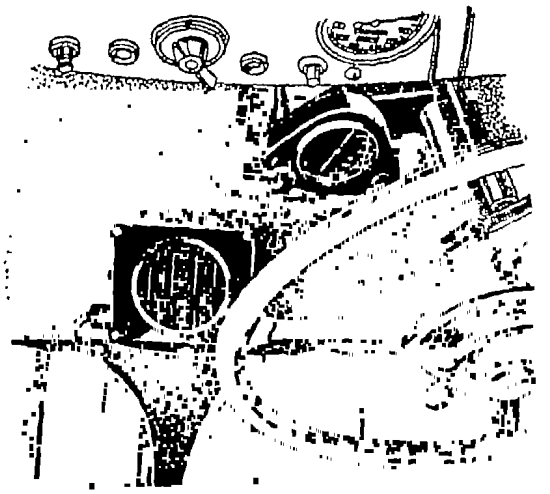
Housing the Set.

The actual housing of the set is sometimes a problem, as if it be located in the rear locker some form of remote control with its attendant lengths of cable become essential. This system has not proved entirely satisfactory, especially in cases where the work has been carried out by someone lacking the specialized knowledge which car radio installation demands.

Generally speaking, the more direct the control the more satisfactory are the results obtained, and from this point of view those sets which are constructed for direct mounting behind the facia board have much in their favour as the operation then becomes precisely the same as a normal set.

Separate or Built-in Loudspeakers.

As to whether the loudspeaker is built into the set or forms a separate unit is purely a matter of taste or convenience in installing. With a separate instrument one has a choice of position in which to erect it; probably the best location being either in the roof or in one corner of a saloon, but here again this is purely a personal matter. In the case of the built-in



A convenient way of installing the Marconi set, the loudspeaker being sunk into the floorboards between the front seats.

speaker its location, of course, depends upon where it is found most convenient to install the set.

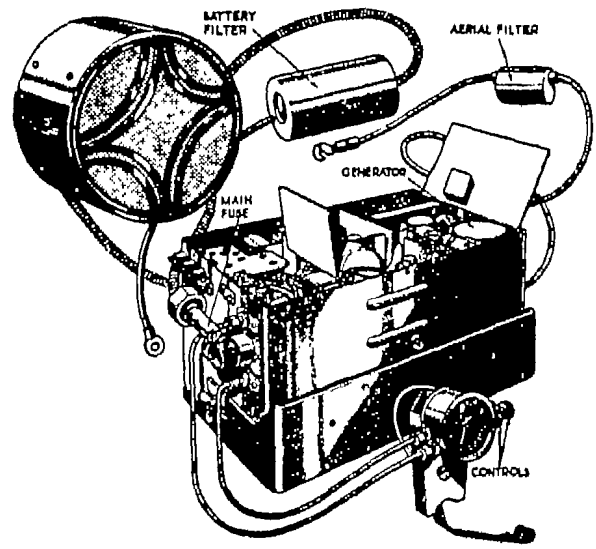
Low Current Consumption.

The actual output required from the set is not large, because as the speaker is enclosed in a small space quite moderate volume suffices in all normal circumstances. Nevertheless, the available capacity of the battery demands attention, as in certain makes of car of the popular type there is but little reserve, especially during the winter months when the car lighting system is being used continuously. This fact has led car radio manufacturers to concentrate on the production of installa-

tions which will run with a current consumption le: than that of one average headlight bulb. There ar(of course, six-volt and twelve-volt radio sets.

Suppressing Interference.

The most important problem which manufacturers (car radio have had to solve is that of suppressin extraneous noises, such as are emitted by the dynam(ignition system, and other pieces of electrical equipmer



The Philips outfit, which includes special filter units eliminating interference from the sparking plugs.

of a car. Such interference suppressors may be of a external type or built into the set itself. In some cas(the interference caused by the spark discharged acro: the sparking plugs is suppressed by means of resistance in the high-tension leads, but as this som(times means adjusting the plug points closer it canno be considered entirely satisfactory. It would seen therefore, that a better system is that in which suc interference is by-passed in the set itself, and this ha been done quite satisfactorily in at least one well-know car radio receiving set.

APPENDIX.

THE following brief explanations, alphabetically arranged, of some of the more important terms and expressions used in the foregoing chapters will be found convenient for quick reference purposes:—

Ammeter. An instrument for measuring current in amperes. On a car it is usually of the central-zero type so that the hand can show "charge" or "discharge."

Ampere. The practical unit of current. In a circuit having a resistance of one ohm a pressure of one volt will cause a flow of current of one ampere.

Armature. The rotating part of a dynamo or a motor. Built up from soft iron laminations and wound with coils of insulated wire.

Battery. A number of cells, generally connected in series, which may be said to store the current generated by a dynamo. Car batteries consist of three or six cells, according to whether they are of the 6-volt or 12-volt type.

Brushes. Metal strips or, more usually, carbon blocks which bear on the commutator of a dynamo or a motor, thus, by means of wires, connecting it electrically with the field windings and/or with an external circuit.

Charge Rate. The amount of current in amperes which is fed to a battery when it is being charged.

Charging. The action of supplying current to a battery. This may be done by the dynamo on the car or by an external source of supply. When the action is complete the battery is said to be fully charged.

Circuit. The path along which an electric current is caused to travel. The wiring system of a car consists of a number of separate circuits.

Commutator. A device secured to the armature shaft of a dynamo or a motor. The armature windings are secured to the commutator bars and on these bear the brushes through which the current flows.

Condenser. A form of electrical buffer or reservoir connected across the contacts of a coil or a magneto contact breaker. It absorbs the follow-on current in the primary winding and, when the voltage ceases to rise, discharges itself by sending a reversed current through the coil. This action prevents sparking at the contact-breaker gap and, in addition, intensifies the secondary, or high tension, discharge.

Conductor. Any substance which allows a current to pass through it. As a rule only those substances which present an easy path for the current are spoken of as conductors.

Contact Breaker. A device which automatically opens and closes a circuit. In ignition systems, either coil or magneto, the contact breaker, by interrupting the flow of current in primary windings, causes a high-voltage current to be induced in the secondary coil.

Cut-out. An automatic switch which disconnects the battery from the dynamo when the voltage of the latter falls to that of the battery. Similarly, the cut-out closes the circuit, i.e. connects the battery, when the dynamo voltage exceeds that of the battery.

Dielectric. The medium which separates two oppositely charged bodies or substances. The resistance of the medium to the electrical strains imposed upon it is spoken of as its dielectric strength.

Distributor. A form of rotary switch by which the high-tension current of a coil or magneto is conveyed, in correct timing sequence, to the sparking plugs. Distributors may be of the jump-spark or wipe-contact type; the first-named is more usual nowadays.

Dynamo. A machine for converting mechanical energy into electrical energy.

Earth Circuit. Actually, a circuit in which the earth forms the return path for the current. In cars the chassis as a whole is regarded as the earth and it is to this that in single-pole wiring systems one terminal of the battery—usually the negative—is connected.

Electrode. A general term applied to such parts as the points of a sparking plug, i.e. the central electrode or the earthed electrodes. The metal leads in a distributor to which the sparks jump from the rotor are also known as electrodes.

Electrolyte. The liquid which supports chemical action in a cell. In the normal lead-acid car battery the electrolyte consists of a sulphuric acid solution having an average specific gravity of about 1.250. In the nickel-iron type of battery a dilute solution of caustic potash forms the electrolyte.

Farad. The electrical unit of capacity. It is far too large for any normal purpose, so that a much smaller unit, the microfarad (one-millionth of a farad) is used. The capacity of a condenser is expressed in microfarads or in decimals thereof.

Fuse wire. The current in amperes at which a wire will fuse depends upon the metal of which it is made and its gauge. The following table forms a useful guide.

Diameter		Current in Amperes		
S.W.G.	Ins.	Copper	Tin	Lead
34	.0092	9.04	1.44	1.21
32	.0108	11.50	1.84	1.55
30	.0124	14.15	2.27	1.90
28	.0148	18.44	2.96	2.48
26	.018	24.75	3.96	3.33
24	.022	33.43	5.36	4.50
22	.028	48.00	7.69	6.46
20	.036	70.00	11.22	9.41

Hydrometer. An instrument for testing the specific gravity of the electrolyte in a cell. It consists of a glass float with a graduated stem and a syringe for drawing a small amount of liquid from the cell. The s.g. is indicated by the height at which the float rides in the liquid.

Induction Coil. Two sets of windings, primary and secondary, encircling an iron core. By means of a contact breaker a low-voltage current passed through the primary winding causes a very high-voltage current to be induced in the secondary winding.

Ohm. The practical unit of electrical resistance. One ampere will be passed through a circuit of one ohm resistance when a pressure of one volt is applied.

Pole Pieces. In a dynamo, a magneto or a motor, the shaped bodies of the field magnets between which the armature rotates.

Rectifier. A device for converting alternating current into direct current. It is used when charging batteries from A.C. mains.

Relay. A device which enables a weak current to cause a stronger one to be switched on. With cars a relay is sometimes used to operate the starter switch.

Resistance. The obstruction offered to the passage of a current. It is measured in ohms.

Solenoid. A coil of wire arranged round a loosely mounted iron core. A flow of current causes the core to move inwards. The principle is used in automatic switches and similar devices.

Volt. The unit of electromotive force or pressure.

Watt. A measure of electrical power; the product of volts × amps. One electrical horse-power equals 746 watts. There is also the kilowatt (1,000 watts), also known as one Board of Trade unit. Domestic electricity is charged for in terms of kilowatts or B.T.U.s.

USEFUL FACTS AND FORMULÆ.

Prefixes.

Meg (a) = one million; as megohm = 1,000,000 ohms.
Micr (o) = one millionth; as microfarad = $\frac{1}{1000000}$ farad
Kilo = one thousand; as kilowatt = 1,000 watts.
Milli = one thousandth; as milliampere = $\frac{1}{1000}$ amp.

Units of Heat.

The British Thermal Unit (B.Th.U.) denotes the heat required to raise 1 lb. (.1 gallon) of water 1 deg. F.

B.Th.U.s × 778 give foot-pounds.

B.Th.U.s per sec. × 1.41 give horse-power.

An Insulating Varnish.

Dissolve flake shellac in methylated spirits or spirits of wine. This varnish, which is obtainable " ready made," besides being an insulator, will protect electrical fittings from the weather.

Soldering Fluxes.

A non-acid flux must always be used for electrical work. Failing one of the special proprietary fluxes, use ordinary resin. Where risk of corrosion is unimportant, " killed spirits," i.e., chloride of zinc, made by dissolving zinc in spirits of salts (hydrochloric acid), is effective with practically all metals save aluminium and cast iron.

Printed in Great Britain by
TEMPLE PRESS LTD.,
5-17 ROSEBERY AVENUE,
E.C.1.